AN INTEGRATED FRAMEWORKFOR CCTV INFRASTRUCTURES DEPLOYMENT IN KSA: TOWARDS AN AUTOMATED SURVEILLANCE

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A thesis submitted in partial fulfilment of the requirements of the University of Northumbria at Newcastle for the degree of Doctor of Philosophy Research undertaken in the Faculty of Engineering and Environment.

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DECLARATION

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others. Any ethical clearance for the research presented in this thesis has been approved.

Approval has been sought and granted by the University Ethics Committee on 15 March 2016.

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ABSTRACT

The process of implementation and installation of CCTV has been a sensitive issue across the world, leading to significant political, economic, social and legal implications. Saudi Arabia, like most countries of the world, has been engaged in the deployment of CCTV surveillance systems for many years now. However, the recent developments, as regards stepping up security against possible terror attacks, has led the decision-makers to begin considering the deployment of a significantly large number of cameras in most sensitive public places across the country. The Saudi laws are based on the Sharia Law which clearly states that no picture/video of any Muslim women or men should be taken without their full consent. In the light of this law, the case for extensive networks of CCTV surveillance has proven to be extremely challenging for the decision-makers in the country. Accordingly, two questions have emerged: 1) how to measure the extent of the cultural and traditional values on the deployment of CCTV systems within the Kingdom? 2) How to develop a framework for effective deployment of CCTV systems in KSA? In the light of these questions, the research has, in addition to the examination of the literature, used three case studies and applied a questionnaire and a number of interviews. The application of statistical techniques revealed several useful findings. The potential safety of CCTV, from respondents point of view, turned out to be highly satisfactory, but a large majority of participants were concerned about two issues: privacy invasion, and controllers' misuse/ abuse of CCTV recordings. The concern about CCTV seems to outweigh the benefits. The study therefore recommends that a nationwide set of regulatory measures need to be developed to incorporate, among many issues, the training programmes for all the control rooms staff, particularly those in charge of public places. Finally, as a potential application of CCTV, the study proposes an automated human detection system based on a Laplacian fitting concept based on human silhouette extraction. With this scheme, a robust human silhouette extraction can be maintained with little human intervention, saving significant amount of man efforts in video processing.

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List of Abbreviations and Acronyms

CCTV	closed-circuit television
DVR	Digital Video Recorder - A digital video recorder is basically a computer that converts the incoming (analog) signal from the cameras to digital, and compresses it, and stores it. The DVR replaces the function of a multiplexor (or quad or switcher) and a security VCR. There are many advantages of digital video recorders over their analog counterparts.
VCR	Videocassette recorder; an electronic device for recording and playing back video images and sound on a videocassette.
RG59	An RG-59 is a common coax cable used in CCTV applications
FPS	Frames Per Second - in digital video applications, refers .to the number of video images. that can be captured, displayed, or recorded in a second. Also referred to as the 'frame rate' or 'refresh rate'.
CAT5	Category 5 (cable) - A type of cable that is used in networking applications.
CAT6	Category 6 (cable) - A type of cable used in networking applications for IP security systems.
PTZ	pan-tilt-zoom - PTZ cameras allow you to adjust the position ('pan' is side-to-side, 'tilt' is up-and-down) and focus ('zoom') of the camera using a remote controller. Due to this added functionality, these cameras tend to cost much more than non-PTZ cameras

VAFPC	VIDEO ANALYTICS FOR PEOPLE COUNTING.
HOSDB	THE HOME OFFICE SCIENTIFIC DEVELOPMENT BRANCH .
VAS	AUTOMATED VIDEO ANALYTICS SYSTEMS .
RG59	AN RG-59 IS A COMMON COAX CABLE USED IN CCTV APPLICATIONS
UAS	UNMANNED AIR CRAFT AYSTEM.
VAFPD	VIDEO ANALYTICS FOR PERIMETER DETECTION.

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CHAPTER 1: INTRODUCTION

1.1 Study Background

In the current state of the world, there are a large number of social problems such as crime, robbery, intrusion etc. Someone at any time maybe a victim to some sort of crime; be it a physical attack, intended harm to life or having an intruder on his or her property. Crime prevention strategies are implemented to reduce the effects caused by crimes. The most widely used technology in crime and theft prevention is the use of CCTV (Closed-Circuit Television) Surveillance System (Agustina and Clavell, 2011). Humans are experiencing the development of technology in modern society like using of CCTV System in crime prevention and people's awareness before most people believe that CCTV system can protect them because offenders know they are being watched and they will not risk their life to commit crimes or deviant act (Gill, 2006).

A common goal of all CCTV surveillance systems is to detect crime and disorder in a timely manner and possibly prevent it. There have also been claims that the very presence of a CCTV surveillance system provides reassurance in the public and thus reduces fear of crime (Yong-Ik and Jee-Ae 2014). Another benefit of CCTV systems is to provide valuable business management tools where by using it can protect staff and support health and safety initiatives (Baker, Al-Gahtani and Hubona, 2007). It also helps in during investigations and providing crucial source of evidence to police and can provide innocence to those people who are not involved (Dumoulin, et al., 2010). Further, it can be helpful in the production and control management in factories where conditions are not suitable. All information in the form of data can be stored and reviewed when needed.

A CCTV System can be designed to fit in all scenarios where it can be installed internally or externally, highly visible or covert, that can be static or moveable depending on position to record and also moveable from remote locations (Ferguson, 2010).

The United Kingdom is one of the forefronts of the CCTV systems deployment in the world with a total of 5.9 million cameras (out of which 750,000 are located in sensitive areas such as schools and hospitals), making it the most watched country with about one camera for every 11 people. These cameras are installed in shopping malls, schools, airports, streets, hospitals, and parking lots. The main purpose of this technology is to monitor behaviour and protect conflicts in various fields of an individual's life and activities (Felson, 2009; Agustina, 2010).

For example, it is estimated that in the UK all of the state schools have CCTV systems in operation to prevent crime and unlawful activities (Taylor, 2010). By investing in CCTV cameras in educational institutions ensures to parents and guardians that the general security and safety of their children are being addressed seriously. Since a CCTV system is monitoring its environment at all times, one of its better uses would be to detect potentially harmful and dangerous situations. In the previous decades a number of research works have been performed in this field in order to detect such potentially harmful situations. For example, Dever et al. (2002) proposed a system that would automatically detect an armed robbery, similarly Marbach, Loepfe et al. 2006) utilised the CCTV network to automatically detect fires in buildings and in high risk areas. CCTV networks can also be used by police to automatically pick up vehicles on the road that are either stolen or have previous criminal history (Jang and Turk 2011).

In the light of ever increasing deployment of CCTV worldwide, this research attempts to critically analyse the related works that have been conducted previously in this area of study and understand how CCTV can protect people's lives and their properties. This study, therefore, attempts to address the pros and cons arising from deployment of CCTV system in Saudi Arabia, using other nations' experiences. In so doing, references are made to legal, cultural, religious, traditional and technological issues surrounding deployment of CCTV systems in Saudi Arabia.

Briefly speaking, Saudi Arabia is an oil rich country having the largest oil reserves in the world. It has recently witnessed a massive improvement in economic development in the past 30 years with profound progress in computer technology, health sector, education, housing and environment (WHO, 2007). There are now extensive networks of roads,

highways, motorways, airports, seaports, power plants, and huge industrial complexes which require full protection against crimes of all kinds. With a population of around 26 million with six million expatriates, the country has now embarked on a crucial decision to go ahead with extensive deployment of CCTV systems across the country (Central Department of Statistic & Information, 2013). However, since Saudi Arabia is an Islamic Kingdom following strict Sharia Law, the deployment of CCTV cameras has proven to go contrary with the Islamic laws, hence has produced a socio-political issue which should be addressed delicately.

In the light of what said above, the case of deployment of CCTV in Saudi Arabia appears to be an interesting research area from both the scientific applications and social/cultural considerations. On the one hand, the country is seen to be in desperate need of further deployment of CCTV systems, particularly in most sensitive public places. On the other hand, the policy makers are expected to approach the social and cultural factors, particularly those relating to Islamic Laws, with extra care, so that a fairer and more effective strategy to be achieved. On the whole, both from technological and social angles, the research on deployment of CCTV systems in KSA is novel and that the findings could be well applied to other countries with similar social/cultural structures.

1.2 Research Aims and Objectives

The aim of this study, therefore, is to examine how CCTV surveillance systems and technologies can be effectively used in Saudi Arabian businesses complying with the country's cultural and religious values and regulations. In so doing, the research also aims to identify the factors that can take part in the effective usage of CCTV systems in Saudi Arabia. The research questions are three-folds, as follows:

I. How the KSA cultural and traditional values affect the deployment of CCTV systems within the kingdom?

II. How to develop a framework for effective deployment of CCTV systems in KSA?

III. How people can be detected from CCTV video?

In order to find answers to the above questions and achieve the aim, the following objectives have been identified:

1. To identify the sources of information to CCTV systems in Saudi Arabia.
2. To design a methodology for the research design and how the research questions can be addressed in a systematic way.
3. To develop data collection methods/ tools and data analysis approaches to validate the methodology.
4. To develop the framework and evaluate it based on the findings from objectives 1–4 to address the research questions.
5. To identify and evaluate CCTV technologies that can be used for surveillance purposes.
6. To conduct a detailed case study on how persons can be detected in CCTV videos..

In the light of the above given questions and objectives of the thesis, the study should therefore consider a large number of factors within the theoretical and analytical frameworks in order to find relevant and workable answers.

1.3 CCTV: The Saudi Experience

With the recent rapid development in all sectors it is very important to protect these premises and the most effective technology can be CCTV Surveillance technology. Although an examination of effectiveness and social costs and benefits of CCTV deployment in other countries can offer insights into such development in Saudi Arabia, religious, cultural and traditional values need to be seriously considered here. According to Swainston (2013) recently the Ministry of Education in Saudi Arabia has announced that CCTV Camera systems are to be installed in around 33,000 schools around the Kingdom in order to protect pupils and students. The main aim of such an initiative is to promote the culture of safety and security among teachers and students along with private security personnel that can be employed to enforce safety regulations (Swainston, 2013). Further, there are 5 million students and 700,000 teachers who are actively involved in their duties and if these steps successful that would be means one third of Saudi students and teacher will not compromise on safety and security.

Therefore, there is a serious need for the deployment of CCTV Surveillance systems in Saudi Arabia and within its booming industry and infrastructure. However, strict Islamic laws may prevent its full deployment because in Islamic laws women or men cannot take picture/video or acquire picture/video unless it is absolutely necessary (e.g., for identification purpose). Therefore, it is very hard to make the case for CCTV systems

deployment. With the government recent initiative, as discussed above, by installing CCTV cameras in 33,000 schools around the kingdom, it will provide better initiative steps for CCTV future in Saudi Arabia. CCTV system will help ensure the physical and operational security around Saudi Arabian businesses, commercial and housing areas. It will protect people, properties, and processes.

In an article on the Hajj security issue, Osborne (2013) reports that currently up to 1700 CCTV cameras are installed in different parts of Makkah monitoring the pilgrims. However, it is anticipated that the number of CCTV cameras in Makkah alone has now increased by three-fold. It is therefore, not surprising to hear that by the end of 2019, CCTV cameras will be installed in almost all public places in Saudi Arabia, where such surveillance systems are expected to grow by 23% (Mathews, 2014). As has been illustrated in Hudson (2012), the significant rise in number of CCTV cameras in Saudi Arabia is imminent, as the issue of security seems to have overshadowed cultural, religious and legal values. This issue has been supported in MEED (2014), when the report warns nations in the GCC to be prepared for the FIFA 2022 World Cup when the states are expected to receive a large number of visitors from all over the world.

On the issue of standards and legal issues, given the limited number of documents from Saudi Arabia, this study attempts to consider a large number of legal documents from other countries, such as UK, GCC, USA, and the EU. This is because as stated in SASO (2013), a Saudi government publication, all legal aspects and standards relating to CCTV in Saudi Arabia fully comply with that of the European standards.

As a part of its severe concentration on the issue of security and deployment of CCTV, the Qatari government has recently stepped up its efforts to proceed with enforcement of new laws governing CCTV installation and use (Doha News, 2014). It is anticipated that other states in the GCC would follow Qatar's legal model of CCTV surveillance in the near future.

In particular, in line with the study's case of Saudi hospital, the Qatari authorities have set up standards relating to deployment, usage and legal structures of CCTV surveillance in healthcare. This law has severely warned hospitals and health centres to install the required CCTV cameras or face losing their licenses (Doha News, 2014).

1.4 CCTV: An Overview of Current Literature

As discussed earlier, in order to meet the objectives of the study and then attempt to find appropriate and workable answers to the questions of the thesis, the literature review must

consider a large number of factors which tend to play their roles in CCTV deployment. In particular, issues such as crime prevention aspect of CCTV deployment, technological constraints, legal and ethical issues, and cultural/religious backgrounds need to be explored and analysed carefully.

One important question raised here relates to the motivations of deploying security cameras for businesses, commercial, educational systems, homes, and so on. The answer can be similar to the need of person's health insurance when they are perfectly right. The security system allows businesses to keep their premises secure from burglaries and crimes. CCTV systems have been widely used tool to provide security against unwanted situation, such as in public places (Hier, 2004), on buses (Poyner, 1998), in parking lots (Tilly, 1993), in small businesses (Hearnden, 1996), as well as for security and crime detection (Norris & McCahill, 2006).

It is important to note here that CCTV systems are not known to be a revolutionary crime prevention measure. Since most government installed CCTV systems cover and monitor public areas and cannot help in preventing physical and sexual assaults carried out in private quarters. In the public areas where they are installed they are known well to perform in city centres where cameras are widely installed. CCTV cameras here have been known to spot and identify less serious offences such as spontaneous flare ups between individuals. But the response time of these events from the police is usually very slow and these individuals are identified long after the event (Mucchielli 2011).

When deploying CCTV technology, the role of the human factor is critical in the effectiveness of CCTV surveillance. However, surveillance systems must be considered when the most recent and effective technology is taken into account. This is very true when the system tends to rely on automatic non-human operators (Balak, 1998). Given the importance of operator vigilance and knowing that the CCTV models developed ignore the perceptual cognitive process that is related to the visual monitoring of the operator, it can be understood why many CCTV models do not perform as expected.

Whether supporting or rejecting the idea of CCTV deployment, there is always a valid question to pose about the legality of such surveillance system. Norris and Armstrong (1999) have presented a number of cases where the civil liberty of citizens have been ignored in favour of deployment of CCTV systems which have later proven to have been ineffective in crime reduction. Gill and Spriggs (2005), among many things, have also made a special reference to the issue of privacy and civil liberty in their comprehensive

report of the UK CCTV systems. They have particularly referred to cases where the social costs arising from deployment of CCTV has significantly exceeded the social benefits.

To date, very little research has been conducted in the areas of culture and religion as determinants of CCTV deployment. In looking at different technological and humanistic characters, Cannataci (2009) makes an extensive reference to technology and CCTV as imparting information, privacy and freedom hence denying the basic human rights. He also identifies areas where religious and cultural sensitivities have need to be incorporated into the process of decision-making vis-à-vis deployment of new technically advanced CCTV.

Among a few researchers, Said et al (2007) and Alhadar and McCahill (2011) have considered the role of information technology and the rate of acceptance of IT in Saudi Arabia. Their findings are indicative of the fact that such resilience to IT is primarily fuelled with some mix of cultural and religious issues. However, their study shows that the new surveillance technologies used as a pilot case have not only saved businesses against theft, but also have managed to protect public morality; hence arguing in favour of further deployment of such facilities in the kingdom.

1.5 Research Methodology and Design

A methodology is a set of methods or principles as an art to conduct research and find the research findings. Methodology is not a concept which provides solution to the research problem but offers theoretical model, qualitative and quantitative techniques to search more problem oriented question and find their answers. There are two general approaches to conducting research work: deductive, and inductive (Mangan, 2004; Saunders *et al*., 2007). These approaches are designed to offer an indication of the overall nature of any possible link between the research and its underpinning theory (Bryaman, 2004).

According to the deductive approach, researchers deduce their studies' hypotheses based on some known facts or theories, and then translate them into operational terms for testing them by the use of statistical methods (Bryaman, 2004, Sunders et al, 2007). The inductive approach, on the other hand, starts from a set of observations to build a theory. In effect, a theory is introduced by making a number of general suggestions concerning what has been observed during a particular timescale, and their nature (Anderson, 2004).

Therefore, a deductive research starts with the existing theories and concepts, and formulates hypotheses that are later tested with the help of empirical data. On the other hand, inductive research starts with the empirical data, and the result is the emergence of

concepts, models, and eventually theories (Gummesson, 2000; Stiles, 2003). Furthermore, it is also recognised that the deductive approach is built on the meaning established from the data analysis through rational generalisation of a known fact; on the other hand, when conducting an inductive approach, emphasis is instead directed towards general suggestions in consideration of known facts (Sekaran, 2003). On the basis of what has been stated, this research is therefore mainly deductive despite being based on triangulation methods of primary data collection.

The choice and the process of undertaking a research represents the research strategy which is the most important part of any study. This in turn, depends on the aims, objectives and the questions of research. Whether adopting a deductive or an inductive approach, the research is then faced with the question of how to carry it out. If a deductive approach has been undertaken, the researcher is expected to employ experimental or survey strategies. On the other hand, when adopting an inductive approach, the researcher is expected to employ the strategies of case study, grounded theory and action research (Hair et al, 2003). On the basis of the study's questions and objectives, a survey approach is to be undertaken.

The rationale for the choice of survey strategy is many-fold. First, the survey method is usually associated with the deductive approach as it is the most appropriate used strategy in this study. Second, this is the most appropriate strategy when data is to be collected from a sizeable sample of population at a particular time, as a large sample size would lead to unbiased estimates for the model under investigation (Leedy & Ormrod, 2005). Finally, survey-based research (quantitative approach) seeks to identify relationships that are common across organisations and, therefore, provide a general statement upon, or a theory about, the phenomenon being researched (Bryman, 1993 and Eldabi et al., 2002).

Once the research strategy has been identified, the next step is how to implement it. The process of implementation of the strategy is referred to as research design. The research design can be viewed as a combination of the art and science involved in the planning processes for carrying out the study in an attempt to garner the most conclusive outcome (Churchill and Brown, 2004; Saunders et al., 2009). Undoubtedly, decisions on the design of research is highly crucial, as it can have a significant impact on the entire study, as it provides a detailed overview of how the study should be guided and directed (Oppenheim, 2000; Collis & Hussey, 2009). Establishing the study design can be viewed as the development of a detailed plan, helping the researcher in identifying and removing any obstacles associated with the study. As has been highlighted in Saunders et al. (2009),

research design is all about a plan which highlights how the research objectives can be achieved.

Creswell (2003) has recommended that researchers should select the study design during the initial phases of the study, as the design will enable one to establish a number of other important elements, including the methodology, data collection methods, and data analysis techniques. Hussey & Hussey (1997), on the other hand, state that the research design process should be periodically reviewed to overcome any new developments in theoretical structure and the study questions. On the basis of what has already been discussed earlier, the research relies on the development of a questionnaire to be completed by customers and employees of a number of businesses; and a series of semi-structured interviews, and then proceeding with the use of appropriate methods of investigation. In short, the design of the research is one of a survey, for which the data and other information is collected through questionnaire and interviews.

The main benefit of selecting a questionnaire approach is to collect large amount of people in a short time period in a relatively cost effective and the results can be easily quantified with the use of software packages (e.g. MS Excel). Further, it also helps to improve research validity and reliability. However, there are disadvantages of choosing questionnaire as well. The amount of truth put in by the respondent is also not known. Sometime they ignore to answer especially in Saudi Arabia where the author faced same problem again and again. Therefore, this investigation plans to use other way for data generation method for future analysis these can be survey, case studies, observation, experiments, documents, and so on.

1.6 Case Studies

In this study, three cases studies are selected: two medical centres and jewellery. The choice of these cases is based on two main reasons. First, these cases cover both public and private domains in Saudi Arabia; hence providing an opportunity of comparing the two sectors' views and use of CCTV surveillance systems. Secondly, both establishments are large enough to provide us with required sample size for statistical analysis.

As for the hospitals, their vision statements are clearly based on gaining public trust and maintaining high health care standards. These two hospitals employ around 600 full time physicians and well over 3000 paramedical and support staff with thousands of patients visiting every day. Further, the Specialized Medical Centre (SMC) Hospital consisting of 450 inpatient beds and over 140 outpatient clinics is served by dedicated and highly

qualified teams. Unfortunately, there is yet no CCTV Surveillance system installed in these premises. Despite the presence of a large number of security guards on different floors and important areas, full security cannot be maintained without the use of CCTV surveillance system. Therefore, choosing this hospital as a case study would help the research to make a strong case where the necessary application of technology has been denied at the expense of cultural and traditional values. The research will also be focused on what cultural and trust issues make it difficult to utilize CCTV systems.

The third case study, Alfardan Jewellery, is one of the biggest businesses in Saudi Arabia with several branches across the country. However, in a recent investigation, it has been found that CCTV surveillance systems installed in this business is yet very limited. The cameras are installed in few areas such as on doors and around the buildings but not inside the stores, warehouses or offices. The jewellery can be worth millions of Saudi Riyals and it is important to install CCTV systems especially in stores where customers mostly visit and warehouses where all the stock is in place. In this case study, it is expected to find main causes that prevent the business from installing the visual surveillance systems in these important sites. Further, the examination of this case will tell us what benefits businesses will get from installing CCTV system in comparison with the similar businesses in the world. Finally, an application of CCTV to detect and extract human bodies from CCTV video, which is an important task to detect abnormal behaviour or person identification, has been investigated and a solution proposed.

1.7 Contributions

A large number of research works has recently emerged in the area of CCTV system deployment in different parts of the Middle East. However, to date, no genuine academic output has come out to consider all aspects of deployment of CCTV in Saudi Arabia. In particular, very little work has considered the cultural and religious aspects of Saudi Arabia and their impacts on the effective deployment of CCTV systems in the country.

The findings from the current research is deemed to enable the academicians and decision makers to identify and evaluate the extent of effectiveness of social, political, economic, cultural, and technological factors against security enhancement in shaping the resistance to deployment of the CCTV system. The research has conducted a detailed analysis of the use of management and how to adopt technology in control rooms for fully exploiting benefits of CCTV deployment in the KSA.

It is recommended in this thesis that action recognition should be considered as an important topic as research and development strategy with a view to develop a working prototype system for inclusion in a telesurveillance system. Furthermore, the research has addressed the limitations of human silhouette extraction has proposed a contribution into an effective silhouette extraction scheme for people detection from video which is an essential task in telesurveillance applications.

1.8 Limitations

In relation to the limitations and drawbacks, this work is of no exception. Although the current research has attempted to examine a large sample size of individual's perception about CCTV deployment in KSA, it only has considered three cases. Moreover, the main concentration of the survey relates to the capital city, Riyadh, which only represents a quarter of the total population of the country. Furthermore, future research may consider other strategies for the collection of further information through interviews or short questionnaires, from policy-decision-makers, end users and technology developers.

1.9 Thesis Structure

The thesis is organised as follows:

Chapter two gives a comprehensive review of the relevant literature in both European/American and Middle Eastern contexts. The literature is designed to cover a large number of aspects associated to deployment of CCTV technology including legal, religious, cultural, technological and privacy versus security.

Chapter Three is concerned with an introduction to the methodological issues in relation to the broad studies of socio-political and technological angles are examined in this chapter. The specific methodology, design and implementation of the methodology in relation to the subject of CCTV deployment is discussed in detail.

Chapter Four is concerned with the analysis of the findings relating to the methodology used. In this chapter the participants of the questionnaires and interviews carried out are examined before a statistical analysis of the results is examined. Final analysis is then discussed.

Chapter Five discusses the proposed framework by highlighting the main areas of the recommendations suggested of this investigation including risk and security requirements, legal and technical issues and technical aspects. The chapter concludes with the recommendations made.

Chapter Six discusses findings relating some practical applications of CCTV technology in KSA including people detection, action recognition, gender recognition and face recognition. The investigation was carried out in relation to the requirements discussed with the stakeholders as part of the case study.

Chapter Seven discusses an investigation of a case study relating to person's tracking from video data and its future application to CCTV deployment in KSA. The main contribution of this chapter relates to a novel detection and extraction of human silhouettes taken from CCTV video data using the concept of foreground and background subtraction methods. The idea is to use the tracked silhouettes to detect people for other applications such as abnormal behaviour or person recognition.

Chapter Eight reviews the main contributions made as part of this investigation. The Chapter also discusses the recommendations made including limitations of the investigation. Finally, some future work is also highlighted.

1.10 Summary

The principal focus of this chapter has been to provide a platform and background relating to the issues perceived as being the most problematic in evaluating the effectiveness of CCTV Surveillance System implementation in Saudi Arabia. The chapter has also made a brief reference to potential problems in each stage in the system deployment with the obstacles that should be considered before a successful implementation of CCTV systems in Saudi Arabia. This is because the changes in technology always have considerable influence in the planning and implementation of new strategies. As discussed in the background research above most of the crime and burglaries are significantly reduced by using CCTV Surveillance system in business, commercial and residential areas. It helps police in investigation and provides crucial evidence against suspects to provide quick justice. However, there are many factors that hinder the growth of implementing CCTV Surveillance system in Saudi Arabia.

The methodological approach has been demonstrated to be based on a mixed method of qualitative and quantitative, using questionnaires and interviews, mostly conducted from customers and staff of the three cases (two Hospitals and Jewellery store).

What is remained to be determined in the case of CCTV in Saudi Arabia suggests that when security issues are considered, all the other factors such as legal and religious/cultural values can be relaxed. This can give rise to the fact that Saudi Arabia

will be experiencing much greater growth in the number of cases of CCTV deployment for the years to come.

However, similar case studies of the effectiveness of CCTV have been investigated worldwide (US and European countries) and the most evaluative findings have led to unclear and inconsistent recommendations (Phillips, 2001; Gill & Spraggs, 2005; Lepon and Popkin, 2007; Taylor, 2010). In short, however, as has been suggested by most researchers, the question of potential effectiveness of CCTV systems should be considered in association with a large number of social, economic, legal, cultural and religious factors shaping our modern life.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In the current state of the world, there are a large number of social problems such as crime, robbery, intrusion etc. Someone at any time could be a victim to some sort of crime; be it a physical attack, intended harm to life or having an intrusion his or her property or infrastructure attack. Crime prevention strategies are proposed and implemented and tackle crimes before they are actually take place. The most widely used technology in crime and theft and prevention is the use of CCTV (Closed-Circuit Television) surveillance system (Agustina and Clavell, 2011). People across the world are experiencing the development or deployment of such technology in modern society as most people tend to believe that CCTV system can protect them against crime. Moreover, it is perceived that offenders know they are being watched and they may not risk their life to commit crimes or deviant act (Gill, 2006). In short, the awareness of CCTV deployment and its perceived usefulness can help reduce crime and ensure safety of people and protection of properties.

This chapter attempts to critically analyse the related works that have been conducted previously in this area of study and understand how a CCTV system can protect peoples' lives and properties. Therefore, in line with the aims, objectives and questions of the thesis, the chapter attempts to address the pros and cons arising from the deployment of CCTV system in Saudi Arabia, using other nations' experiences. In doing so, references are made to legal, cultural, religious, traditional and technological issues surrounding deployment of CCTV systems in Saudi Arabia.

The literature review summary is presented in table 2.1, offering the list of the selection of main contributions and brief description of their research, used in this chapter. The process of selection of the areas of research and authors is based on consultation and reference to a number of recommendations made by previous researchers in this area. In addition to technological issues associated with CCTV systems, cultural/social issues are extremely important, particularly in relation to deployment of CCTV in KSA. Furthermore, a number of legal matters which have been seriously challenging the deployment of CCTV in the Western countries have also been considered in this research.

Table 0.1 Summary List of Selected Literature used

Heading	Author(s)	Title	Brief Finding(s)
Background	Baker et al (2007)	The effects of gender and age on new technology implementation in a developing country.	Presents a brief account of the effects of CCTV surveillance on everyday life
	Taylor (2010)	UK schools CCTV and the Data Protection Act 1998	Considers a number of legal issues relating to CCTV data protection with reference to schools in UK.
	Roberts (2011)	The history of video surveillance: from VCRs to eyes in the sky.	Offers a detailed review of development and deployment of CCTV since late 1940s.
Crime Prevention	Norris and McCahill, (2006)	CCTV: Beyond penal modernism?	Presents cases of crime prevention in some UK places after deployment of CCTV
	Gill & Spriggs (2005)	Assessing the impact of CCTV	A very detailed analysis of costs and benefits of CCTV deployment in the UK.
	Yokotea et al (2010)	Introduction of security camera system with privacy protection into a residential area	A case study of three areas in Japan with the experience of potential crime reduction using new CCTV installation.
	Goold (2000)	Public area surveillance and police work: the impact of CCTV on police behaviour and autonomy.	The research examines a survey of the police control room efficiency and conduct. He suggests that the police must be monitored to stop them from

			gaining unauthorised access to incriminating video evidence.
Crime Prevention	Held et al (2012)	Intelligence video surveillance	Using an intelligent sensor the authors report that such cameras have turned to be effective in crime reduction
Technology	Gill and Spriggs (2005)	Assessing the impact of CCTV	The study highlights the importance of the control room operation as an important determinant of a CCTV system's ability to deter crime. They report that half of the control rooms in their study were found to be monitoring less than 24 hours a day.
	Straub et al (1997)	Testing the technology acceptance across cultures: A three country study	Based on the technology acceptance model (TAM), study examined three developed countries: Japan, USA and Switzerland. The conclusion is that although there is abundant technology in these countries, yet the rate of acceptance is significantly lower in Japan than the other two countries.

	Said et al (2007)	Information Technology in Saudi Arabia: The acceptance of use of IT	Having surveyed a number of cases in different countries, the study has concluded that there exists low rate of technological acceptance amongst businesses and the public at large.
	Sarfraz et al (2013)	Real-time automatic license plate recognition for CCTV forensic applications	The author has come up with a novel approach for efficient localization of license plates in video sequence and the use of a revised version of an existing technique for tracking and recognition.
Legal/Ethical	Gras (2004	The legal regulation of CCTV in Europe	The study argues that CCTV surveillance has led to changes in definition of privacy and hence creating a challenging arena for regulators and lawyers in most European countries
	Gill & Spriggs (2005)	CCTV: Beyond penal modernism?	The authors have presented a number of cases where the civil liberty of citizens have been ignored in favour of deployment of CCTV systems which have later proven to have been ineffective in crime reduction.

Culture & Religion	Alhadar & McCahill (2011)	The use of surveillance cameras in a Riyadh shopping mall: protecting profits or morality?	The authors argue that the new surveillance technologies used as a pilot case in a Saudi shopping mall not only has saved businesses against theft, but also has managed to protect public morality.
	Budak and Rajh (2014)	Citizens' Privacy Concerns: Does National Culture Matter?	They argue that the more the people are made aware of the usefulness of the CCTV the lesser will be the adverse impact of culture and religious aspects on deployment of the surveillance systems.
	Hidalgo et al (2014)	Citizens' Perception on Surveillance, Security and Privacy: A Psychosocial Perspective?	The study point out to the fact that even in a given country, people's attitudes can change significantly depending on where they live and what they have been experiencing.

2.2 CCTV System: Background Information

It is believed that the earliest documented use of CCTV technology goes back to the 2nd World War, where a simple version of TV monitor was designed by Walter Bruch and used in 1942 in Germany to protect and monitor the notorious V-2 rockets. However, it was not until 1949 that the technology was adopted and used on commercial bases in USA (Roberts, 2011). These simple systems were initially installed in sensitive and logistic military places, but later proven to be of great assistance in protecting businesses and other public places alike.

The earlier version of these cameras had no recording facilities, but later in the late 1950s the primitive reel-to-reel recording systems were introduced to help preserve the data gathered. The magnetic tapes which had to be swapped manually, proved to be a time-

consuming and costly process. It can be argued that a major development in the history of CCTV systems happened when video cassette recordings became widely available in the mid-1970s; and was quickly incorporated into surveillance systems, offering a new way for the cameras to be used. Under this system, the cameras could be set up and left to run by themselves; where the reviewers could study the information recorded later. However, there was a problem with this system as the tapes had to be changed on a regular basis or re-written.

With the emergence of multiplexing during the 1990s, and digital video recording, it became possible for video signals from a number of CCTVs to be combined and displayed on one monitor. This step forward made CCTV systems more efficient and it helped to increase their popularity in almost all types of businesses and public places. Furthermore, the development in digital technology since the turn of the millennium has enabled VCRs to be replaced with digital video recorders (DVRs), making CCTV systems simpler and more user-friendly (Roberts, 2011).

A common goal of all CCTV surveillance systems is to detect crime and disorder in a timely manner and to possibly prevent it. There have also been claims that the very presence of a CCTV surveillance system provides deterrent and reassurance to the public and thus reduces fear of crime (Yong-Ik and Jee-Ae 2014). Another benefit of CCTV systems is to provide valuable business management tools, where by using it can protect staff and support health and safety initiatives (Baker, Al-Gahtani and Hubona, 2007). It also helps during investigations and providing a crucial source of evidence to police and can provide innocence to those people who are not involved (Dumoulin, et al., 2010). Further, it can be helpful in the production and control management in factories where conditions are not suitable. All information in the form of data can be stored and reviewed when needed.

A CCTV System can be designed to fit in all scenarios where it can be installed internally or externally, highly visible or covert, that can be static or moveable depending on position to record and also moveable from remote locations (Ferguson, 2010).

According to the Telegraph Report (2013), in the UK alone there are a total of 5.9 million cameras (out of which 750,000 are located in sensitive areas such as schools and hospitals) which comes to about one camera for every 11 people in the UK. These cameras are installed in shopping malls, schools, airports, streets, hospitals, and parking

lots. The main purpose of this technology is to monitor behaviour and protect conflicts in various fields of an individual's life and activities (Felson, 2009; Agustina, 2010).

It is estimated that in the UK all of the state schools have CCTV systems in operation to prevent crime and unlawful activities (Taylor, 2010). Investing in CCTV cameras in educational institutions ensures parents and guardians that the general security and safety of their children are being addressed seriously. Since a CCTV system is monitoring its environment at all times, one of its better uses would be to detect potentially harmful and dangerous situations. In the previous decades a number of research works have been performed in this field in order to detect such potentially harmful situations. For example, Dever (2002) proposed a system that would automatically detect an armed robbery. Similarly, Marbach (2006) utilised the CCTV network to automatically detect fires in buildings and in high risk areas. CCTV networks can also be used by police to automatically pick up vehicles on the road that are either stolen or have previous criminal history (Jang and Turk, 2011).

2.3 CCTV: Crime Preventer or Intruder

One important question raised here relates to the motivations of deploying security cameras for businesses, commercial, educational systems, homes, etc. The answer can be similar to the need of individuals' health insurance when they are perfectly healthy. The security system allows businesses to keep their premises secure from burglaries and crimes. CCTV systems have been widely used to provide security against unwanted situation, such as in public places (Hier, 2004), on buses (Poyner, 1998), in parking lots (Tilly, 1993), in small businesses (Hearnden, 1996), as well as for security and crime detection (Norris and McCahill, 2006).

The characteristics that help determine whether a CCTV system has met its objectives in reducing crime can fall under the following five headings:

i) scheme objectives; ii) management; iii) density of the area; iv) camera coverage and positioning; v) technical and operational features of the control room (Burrows, 1979). If any of the above five factors fails to correctly meet the objectives, then it can be argued that the system has failed to achieve the required net benefits in reducing/eliminating crimes.

According to Lipton et al. (2003), the world has changed in terms of security after the 9-11 terrorist attacks and the security is not only required for large military or government installations but also for hospitals, commercial areas, and residential areas. The act of

terrorism or crime can have the ability to cause a huge amount of damage such as economic and environmental damage, and fall in national moral and loss of human life. Therefore, a CCTV system can provide a full potential as a real-time security system to protect critical infrastructure (The Transport Security Administration [TSA], 2007). Further, video surveillance system is an excellent tool to protect against real-time nature of threats, pattern of attacks and deter crimes.

According to Gill and Spriggs (2005) CCTV Surveillance System works best in small enclosed areas where there is an increased chance of crime. Evidence from the UK shows the use of CCTV system can reduce the theft of vehicles and other form of acquisition theft (Clark, 2001). Express News UK (2010) has reported that UK is the most watched country in the world where councils in different localities in the last three years have spent well over £300 million on installing CCTV cameras. Further, cameras provide a deterrent to criminals and make people feel safer. According to Kelly (2010), for every 1,000 CCTV cameras only one crime is solved per year in the United Kingdom. This, therefore, means that the CCTV systems appear to have failed to be effective in solving crimes in the UK.

The research carried out by Gill and Spriggs (2005), funded by the Home Office, ca be regarded as one of the most comprehensive and fundamental studies which has been conducted in Europe. The research examines public attitudes before and after the installation of CCTV in 12 different areas of the UK. When measuring the effectiveness of CCTV in crime reduction in the controlled areas, the study has come up with some interesting findings and recommendations. Using a cost-benefit approach in measuring the effectiveness of the CCTV surveillance installation, the study has attached some monetary values to unit costs of different crimes in these areas. The study shows that with the exception of violence against person, all other types of crime are shown to have decreased following the installation of CCTV in these areas. In particular, theft of all kinds has been reduced significantly, according to this study. On the whole, Gill and Spriggs (2005) demonstrate that the installation of CCTV in selected UK cities and towns have generated a net benefit giving a cost-benefit ratio of 1.24, meaning that every £1 spent on CCTV system, £1.24 worth of benefit has been achieved.

On examination of the current data protection and safeguard, Coudert (2009) has argued that the data collected from CCTV has been, to some extent, used by other parties, presumably for the purpose of public safety. By offering a number of cases where data protection could be violating the human rights the author has recommended a new system

of safeguarding such sensitive data. Coudert, therefore, calls for a specific focus to be put on the need for a greater involvement of controllers in the identification and management of privacy risks through the use of tools such as Privacy Impact Assessments, and of independent authorities such as data protection authorities in control of systems highly sensitive in terms of fundamental rights. However, as Coudert (2009: 154) concludes, the more pressing need lies with the "redefinition of transparency instruments able to ensure a fair balance between 'watchers' and 'watched'. To that effect, new mechanisms should be devised that could both guarantee the accountability of controllers and generate sufficient trust for individuals".

On an examination of the security camera system with privacy protection, Yokotea et al. (2010) have considered a residential area in Japan. In their experiment, the security camera system is capable of monitoring the houses, as well as the public space in front of the house. However, as they report, the monitoring of a public space has the risk of privacy violation and there had been reports of complaints from several households in the area, despite the privacy, protection function was added to prevent this risk.

A research study was undertaken by the University of Sydney (2010) into whether a CCTV surveillance system creates safer streets or has no effect on the city of Sydney, Australia. The research was undertaken in two parts, the first part before the installation of six cameras and the second part of the report was after the installation of CCTV surveillance systems. The study revealed that the installation of security cameras makes a huge change to public life, as the public feel more secure than before. Moreover, the research has identified areas where such CCTV systems have given potential criminals the perception that they are being constantly watched and hence deterring them from offenses and crimes. Similarly, in the case of recently held Olympics in London, where security measures were taken seriously to avoid any unwanted situations, the Guardian (2012) reports that dozens of cameras were installed around the playgrounds in order to scan the crowds, tourists or spectators to protect from any violent situations. The plan was successful and there was not even single incident of crime reported during the London Olympics 2012.

Among many areas relating to the effectiveness of CCTV in the UK, Keval and Sasse (2010) have pointed out the potential weaknesses associated with such cameras, primarily to do with lack of communication between the operators and the management. According to these researchers, such issues have led to severe lack of effectiveness of CCTV systems across the country. The study is based on a structured observation and semi-structured

interviews of 13 managers and 38 operators at 13 control rooms. In addition to lack of communication, among the members of control rooms, Keval and Sasse (2010) also identified a number of failures including; poor technology configuration, poor quality recordings and a lack of system integration.

It is important to note here that CCTV systems are not known to be a revolutionary crime prevention measure. Since most government installed CCTV systems cover and monitor public areas and cannot help in preventing physical and sexual assaults carried out in private quarters. In the public areas where they are installed they are known well to perform in city centres where cameras are widely installed. CCTV cameras here have been known to spot and identify less serious offences such as spontaneous flare ups between individuals. But the response time of these events from the police is usually very slow and these individuals are identified long after the event (Mucchielli 2011).

To assess its potential effectiveness, studies carried out in a number of French towns have shown that (excluding traffic offences) CCTV cameras were able to detect between only 1 and 2 percent of annual street crime prevention (Mucchielli 2011). Currently the call for request for CCTV footage to be used in legal proceedings is also very low and to date very few prosecutions have been made in criminal cases using CCTV footage.

According to Mucchielli (2011) CCTV cameras are in no way a replacement for police presence. For the cameras to be used effectively there should always be a live link between the camera and a monitoring station. Furthermore, there should be enough officers on duty to respond to a threat detected. Thus for CCTV to work as a crime prevention tool it should be used as a form of additional support and its overall costs (both monetary and social) must be fully determined prior to installation (Brands et al. 2013).

In tackling the costs associated to crime in hospitals, Cocks (2003) reports the way CCTV deployment has managed to reduce crime in the Camden area, London. He argues that once crime in hospital is reduced then the associated net benefits are accrued to patients, staff and visitors. In making sure that the project would work effectively, Cocks (2003) proposes that in-house training about the usefulness and operation of surveillance systems should be introduced to increase awareness and efficiency.

In an earlier work, Goold (2000) has demonstrated that there appears to be areas in which the police can misuse the evidence from CCTV by gaining unauthorised access to incriminating video evidence. He argues that in such cases, CCTV appears to be a nuisance and an intrusion rather than helping reduce crime. Furthermore, in a study of

crime displacement, Cerezo (2013) has reported that the use of CCTV has reduced crime but such crimes have been displaced to other nearby areas. Hence, the overall effectiveness of CCTV in crime reduction has been doubted. This finding is extremely important for policy makers and operators as the issue of CCTV locations and coverage need to be pre-examined prior to deployment of such cameras.

In consideration of the costs and privacy effectiveness of the existing CCTV cameras in Pattaya City, Japan, Prashyanusorn et al (2011) have come up with several recommendations. The authors propose a combination of existing CCTV system and the e-JIKEI Cameras system to be used in patrolling for only the crowded, and the huge number of the e-JIKEI Cameras to monitor the dead-angle of the CCTV in the busy area. In addition, they suggest that by installing a number of e-JIKEI Cameras in quiet residential areas the safety of the whole city will be increased significantly. As for the memory capacity of the system, Prashyanusorn et al (2011) argue that if it is sufficiently large, then there would be no need to spend time to save a selection of images, and hence all images can be saved for future references. On the other hand, in a real world the memory capacity turns out to be small and that memory needs to be conserved. In this situation, an appropriate selection of video/images needs to be done in relation to the previous experiences of the operators in consultation with the law and order officers.

On the development of a more robust and reliable system of surveillance for a large geographical entity, Ajiboye et al (2015) have proposed a framework that allows access to data from privately owned cameras, with the aim of increasing the efficiency and accuracy of public safety. They argue that the accuracy of results obtained from government-owned public safety infrastructure would improve greatly if privately owned surveillance systems 'expose' relevant video-generated metadata events, such as triggered alerts and a metadata repository. In this case, a police officer, for instance, with an appropriate level of system permission can query unified video systems across a large geographical area such as a city or a country to predict the location of an interesting entity, such as a pedestrian or a vehicle. They therefore conclude that this system would present a new hierarchical architecture, known as Fused Video Surveillance Architecture (FVSA). FVSA is comprised of a hardware framework being supported by a multi-layer software interface that presents video surveillance systems as an improved computational grid of intelligent services, capable of communicating with other compatible systems.

On a review of several aspects of the CCTV and the intelligent video surveillance systems, Held et al (2012) have made a comparison between the conventional cameras

and those of intelligent ones which can recognise or track objects as well as identify human faces and behaviour patterns. By making a reference to a recent social-psychological analysis of individuals who have been monitored by either types of surveillance, they argue that the subjects felt more uncomfortable compared to those who were not exposed to any form of CCTV. The study also states that those who were monitored constantly appeared to avoid monitored spaces more frequently and hence became more aware and conscious of their behaviour.

Similarly, such behavioural changes in drivers who were monitored by a traffic control system in Saudi Arabia have been reported in Jan (2014). The study reports that such traffic control surveillance system has also been effective in reducing traffic offenses significantly in and around the monitored area.

One possible explanation for lack of effectiveness of the CCTV has been highlighted in Donald (2010) as being the insufficient attention devoted to the human side of CCTV systems and detection processes, namely CCTV surveillance control room operators. It is expected that these operators must sustain high levels of alertness and attention over extended periods of time. Donald (2010) has integrated a whole host of factors into a holistic theoretical model of performance for CCTV operators, covering on areas such as vigilance, human factors in system design, and perceptual-cognitive processes involved in visual search and monitoring. The study concludes that decision-makers must make sure to recruit the control room staff based on their performance on these social, psychological and technological factors.

Rankin et al (2012) have suggested a systematic method of measuring the CCTV operators' performance benchmarking under different situations. Their approach can be done through the use of a range of automated video analytics systems (VAS) to improve efficiency of the operators as well as providing a means of comparing the efficiency derived from VAS with that of the human run operation. According to the findings derived from Rankin et al (2012) study, although the introduction of VAS in some areas of control room has brought about efficiency and improved productivity of the staff, care must be taken in introducing VAS into appropriate control rooms where a larger number of more sensitive areas to be monitored.

Neil et al (2007) examined the performance of the CCTV operators in a number of control rooms, conducted by the Home Office Scientific Development Branch (HOSDB). They report that such performance was measured through filming the staff who were informed

beforehand; they were found to be working harder and concentrating more. The study, therefore, proposes that the performance of control room operators must be routinely checked and tested frequently without them being informed beforehand.

Finally, on effectiveness and appropriateness of CCTV in crime prevention in South Korea, Moon et al (2015) examined a large data set based on the time series relating to crime trends and CCTV installation. The study attempted to identify whether the choice of locations for installation of CCTV systems has anything to do with the effectiveness in crime reduction. The results showed that CCTVs on a whole have failed to reduce crime significantly, primarily due to the fact that they had been installed in the wrong locations. They, therefore, suggest that CCTVs should be installed and managed in a more scientific way reflecting local crime situations. In particular, they suggest that the methods of spatial analysis such as GIS, which can evaluate the installation effect, and the methods of economic analysis like cost-benefit analysis should be developed in identifying the optimum locations and number of CCTV cameras.

2.4 Technological Aspects

The choice of technology can play an important role in the success or failure of deployment, implementation and the outcome of a CCTV surveillance system. This can result from as simple as the choice of the cameras and their location, the location of control room to and the use of up to date computer or automated software.

|Video analytics for surveillance has now grown momentum worldwide. The reason for this is the rapid proliferation of CCTV cameras in major public areas such as shopping malls, airports, train stations, underground stations etc. The vast scale of CCTV deployment in almost every area of life has called for the need of automation or semi automation in CCTV surveillance. This is because human operators simply cannot monitor this many CCTV cameras for an extended period of time. Limited automation in CCTV is already in use in the form of automated number plate recognition (ANPR) and this has served to be very useful to enforce road safety and traffic rules throughout Britain and around the world. Based on this, interest is being developed and more funding is being made available into the research of automation in CCTV focusing on detection and tracking of people, which may be an individual, group or a crowd (Adams, et al, 2010).

When deploying CCTV, the role of the human factor is of utmost importance in the effectiveness of CCTV surveillance. However, surveillance systems must be considered

when the most recent and effective technology is taken into account. This is very true when the system tends to rely on automatic non-human operators (Balak, 1998). Given the importance of operator vigilance and knowing that the CCTV models developed ignore the perceptual cognitive process that is related to the visual monitoring of the operator, it can be understood why many CCTV models do not perform as expected. The paper, therefore, lends itself to supporting a more comprehensive, structured and continuous programme of monitoring and training operators.

On a similar issue, Gill and Spriggs (2005) highlight the importance of the control room operation as an important determinant of a CCTV system's ability to deter crime. They report that half of the control rooms in their study were found to be monitoring less than 24 hours a day. They argue that had there been more intelligence and communication among the public and the control room operators, more crimes would have been deterred and more savings made. As in some localities the study finds lack of commitment and proper management as detriment to effectiveness of CCTV, it therefore recommends that a nation-wide programme of training, and management of control rooms to be implemented.

There are different deployment procedures for CCTV Cameras. The most secure system is based on VPN (Virtual Private Network) deployment method where a private tunnel is virtually created for transmission packets (DIPOL, 2006). The streaming through VPN tunnels are securely passed through different paths to the destination. This method of deployment is helpful especially in Saudi Arabia where many people have bad ideas about CCTV systems.

Straub et al (1997), based on the technology acceptance model (TAM), examined three developed countries: Japan, USA and Switzerland. They have come up with a conclusion that although there is abundant technology in these countries, yet the rate of acceptance is significantly lower in Japan than the other two countries. A similar model has been applied to Saudi Arabia by Said et al (2007), where the study has concluded that there exists a low rate of technological acceptance amongst businesses and the public at large.

In the study of UK cities CCTV installation and effectiveness, Gill and Spriggs (2005) reported that the cameras used were of the type PTZ (pan, tilt, zoom) which appear to be more likely to be monitored as operators could control with overlapping fields of vision. They also argue that an advantage of PTZ over the other cameras is that they can be seen to be moving, hence giving some kind of reassurance to the public that the cameras are

really in working and operational conditions. However, on the negative side, the study reports that some of these PTZ cameras were found to be unable to cope with artificial lighting in the hours of darkness.

Yokotea et al (2010) have considered a system of surveillance for public safety and security in their research of residential areas in Japan. They argue that because images are encrypted and saved by this function, it is impossible to watch them without the proper key for decryption.

Sheikh and Basalamah (2014) in their study of priority-based routing framework in surveillance networks, highlighted the features of a visual sensor networks (VSN) capable of capturing images and sending them to sink nodes for processing. The paper presents a new routing framework for the VSN to deliver some critical imagery within the system's time constraint, using Contiki and Cooja simulators.

When considering the traditional placement of CCTV within the domain of crime prevention technologies, Menichelli (2014) has proposed a conceptualisation of surveillance cameras that takes into account how different elements interact to shape how these are understood, defined and used in the day-to-day practices of the police. The methodology is based on an ethnographic fieldwork conducted in two medium-sized Italian cities where open-street CCTV systems have been implemented and a number of interviews with police officers in both cities. Menichelli's observations lead to a main and fundamental finding in that cameras were found to have been rarely used and not for reasons pertaining to crime control; rather, they have become a tool for the efficient management of scarce policing resources, with particular emphasis on the co-ordination and real-time tracking of patrolling personnel. This finding has led to the conclusion that implementation of CCTV is based on the interaction of several distinct, yet related, processes and that can explain why the same technology is implemented, defined and used in different ways in similar organisations.

When evaluating the efficiency of the real time automatic license plate recognition (ALPR), Sarfraz et al. (2013) proposed a framework, particularly designed to work on CCTV video footage obtained from cameras that are not dedicated to the use in ALPR. At present, in license plate detection, tracking and recognition are reasonably well-tackled problems with many successful commercial solutions being available. As they argue, the existing ALPR algorithms are based on the assumption that the input video will be obtained through a high-resolution, high-speed camera and is generally controlled using

a capture device, with appropriate camera height, focus, exposure/shutter speed and lighting settings. Sarfraz et al (2013) have come up with a novel approach for efficient localization of license plates in video sequence and the use of a revised version of an existing technique for tracking and recognition. A very special feature of their proposed approach is supposed to be intelligent enough to automatically adjust for varying camera distances and diverse lighting conditions. This is, as they argue, a requirement for a video forensic tool that may operate on videos obtained by a diverse set of unspecified, distributed CCTV cameras.

On an examination of the new generation of multimedia surveillance systems, Hossain (2014) has made reference to a large number of heterogeneous sensors to collect, process, and analyse multimedia data for the case of potential security threats. He explains that some of the major concerns facing these systems are related to scalability, pervasive access to sensory data, and above all, the massive storage requirements. Hossain (2014) considers cloud computing as a tool which can provide a powerful and scalable infrastructure for large-scale storage, processing, and dissemination of sensor data; hence offering new possibilities for efficient development and deployment of sensor-based systems. In essence, Hossain (2014) proposes a framework for a cloud-based multimedia surveillance system that can effectively support the processing overload, storage requirements, ubiquitous access, security, and privacy in large-scale surveillance settings.

To promote the skills and technology in order to detect gun carrying individuals using CCTV, Blechko et al (2008), using the cases of gun crime in the UK, propose the use of body language as means of detection. They argue that individuals carrying or concealed guns normally exhibit some specific signs in their body language when being monitored. According to their study, the size of the influence of carrying a gun or any firearm on a surveillance target's anxiety level was found to be related to the number of times that individual was believed to be carrying a firearm. Furthermore, Blechko et al. (2008) report that a test of body language decoding ability did not show that the body language reading skills of observers were related to the ability to detect a concealed firearm. More recent research work in this area conducted by Grega et al (2013) have laid more emphasis on the skills that human operators can acquire to watch and analyse the potentially dangerous situations such as gun carrying and active shooter events.

In a survey of 13 control rooms in different parts of the UK, Keval and Sasse (2010) have reported a large number of areas where they found that technology has been poorly applied and implemented. In particular, the study has made special references to poor

camera positions, lack of space and camera-to-operator radio, faulty radio tools, and relatively outdated recording systems in a number of control rooms. The study has come up with a number of recommendations in improving technology in a number of locations. First, they recommend that a respectable budget should be allocated to repairs and maintenance of cameras and other facilities. Second, they suggest that the VHS tapes should be disposed of after the fifth use. Finally, they recommend that a software should be develop for cameras and maps to be integrated into one interactive mapping and database system.

Using a survey of video surveillance system with motion detection ability, Shirbhate et al (2012) promote the idea of using an automated, rather than manual, motion sensitive system. This proposed motion detection model based on variational energy provides a vigorous detection at different illumination changes and noise levels without the need for tuning any parameter manually. In support of this model, Shirbhate et al (2012) express that due to its compact structure and efficiency, this model could be implemented in a small and confined system.

Biao-Song et al (2014) have also taken an evaluation of threat-based context-aware surveillance intelligence under different algorithms. Their observations were based on a complex system capable of encryption, de-identification, scrambling and obscuring which eventually manages to identify individuals who behave abnormally in the presence of surveillance systems. Although they believe this system can help reduce crime, bring about more secure environments and reduce social costs associated with crimes, it can seriously jeopardise the legal and privacy issues relating to use of CCTV. They therefore recommend that both technological and legal aspects of such intelligent system need to further improved and discussed over.

In the case of face recognition and detection technology, the past few years have witnessed an increased development and deployment of such facilities in both public and private organisations and strategic locations. Face recognition algorithm can be classed as either reconstructive or discriminative, where both having their own drawbacks and advantages. As has been highlighted in Naseem (2010), the reconstructive algorithm is expected to perform better in the cases of noise or contaminated pixels, whereas the discriminative algorithm appears to perform better in cleaner environments.

On the whole, any face recognition algorithm consists of three parts: (1) face detection; (2) feature extraction; (3) face clarification (Al-Shebani et al. 2013). Using the

appropriate software, it is expected that the entire process can take only a few seconds; though respectable, in terms of security every second counts (Theocharides et al, 2004). There is still room for improvement in terms of both the cameras and the software in so far as security issues are concerned.

To meet both the speed and the accuracy, a face detection method integrating the skin color segmentation and Split up Sparse Network of Winnows (SNoW) has been examined in Wang et al (2010). This method can inherit their common advantage of fast speed by detecting human face areas and then use the way of Continuously Adaptive Mean Shift (CAMS) to track human face areas. The experimental findings of the study show that the proposed method integrating the skin color segmentation with Split up SNoW is superior to each of the single methods separately.

Valera and Velastin (2005) describe the current state-of-the-art of automated visual surveillance systems as to provide researchers in the field with a summary of progress achieved to date and to identify areas where further research is needed. They argue that the ability to recognise objects and humans, and to describe their actions and interactions from information acquired by sensors is essential for automated visual surveillance. The research therefore highlights the ever growing need for intelligent visual surveillance in commercial, law enforcement and military applications makes automated visual surveillance systems one of the main current application domains in computer vision.

In the case of installation of low cost multi featured surveillance system for large organisations, Shekapour et al (2015) have focused on integration of different components for making improvised surveillance system. Given that the incidents of robbery, theft and cybercrime are on the rise, they argue that almost every organisation needs a well-structured system to secure confidential data of one's organisation. The main focus of their research therefore is on combining different components which can help a single organisation to secure its data from all possible threats. Shekapor et al (2015) further argue that using such low cost surveillance system, any suspicious activities can be easily identified and hence crimes to be deterred at source. In short, installation of such system aims to combine different components input and then ends up with one homogeneous output.

Another area of technological development in use of CCTV, though appears to be trivial, has attracted many researchers. CCTVs tend to consume more power and memory space, and that standby electricity leads to significant costs in power consumption. As

Prabhakaran et al (2015) point out, on average around 3 to 12% of residential electricity usage is due to standby power but tend to vary with countries. They therefore suggest that a solution to overcome these problems could be by using a microwave motion sensor which has the ability to detect moving objects as they come within the sensor's detection range and generates an output. This output can be used for further signal processing or activating other devices like recording system and lighting system.

Recently, the introduction and development of the so-called Unmanned Aircraft Systems considered as a potentially useful contributing factor to surveillance worldwide (Sakiyama et al. 2014). Drones are free-flying aircrafts, controlled by remote technology, and are capable of collecting information along their flight path. More importantly, drones are designed to provide visual monitoring of activities in various public places. Initially developed for military purposes, drones are now being developed to use in search and rescue activities. As well as in road and traffic management using sophisticated CCTV systems.

2.5 Legal and Ethical Issues

The implementation of CCTV on such a wide scale has always raised some ethical and legal issues. Furthermore, the lack of ethical regulations on "dumb" CCTV surveillance concerns have been shown worldwide over the misuse of the CCTV footage and in many cases this misuse has been demonstrated as well. Therefore, it is only fair to say that the widespread implementation of such CCTV systems would not be welcomed by the whole population and would come under a lot of scrutiny over how the data collected by CCTV is regulated.

Adams (2007) argued that the regulation of CCTV data is very limited in today's law and is primarily based on existing data protection rules, which is not ideally suited for CCTV data. Similarly, the development of Japanese Data Protection has shown that CCTV is regulated under very weak data protection legislation. Even though deployments of CCTV in Japan are gaining popularity at an alarming rate (being installed in public, semi-public and even semi-private such as work place canteen areas) and yet this issue is still seen as non-problematic and is not regulated effectively (Adams, et al, 2012).

As the number of CCTV systems in public places has been growing exponentially across the world, tight laws and regulatory measures are now becoming both necessary and desirable. In a comparative evaluation of regulations regarding CCTV across large

European countries, Gras (2004) has attempted to arrive at a minimum standards furnishing the safeguard of citizens and their human rights. “The efficacy of regulation will depend not only on its quality, but more on a country’s commitment to privacy and the institutional safeguards it has already installed to protect it” (Gras, 2004: 228). In short, Gras (2004) argues that CCTV surveillance has led to changes in definition of privacy and hence creating a challenging arena for regulators and lawyers in most European countries.

A similar survey relating to data privacy and regulation in Africa has been conducted by Makulilo (2012) is indicative of the fact that its current state is underdeveloped. By considering issues such as data privacy policies, culture and religion, the study has come up with concluding remarks that due to lack of democratic experiences, prevalence of collectivism culture and strong religious backgrounds Africa remains to be far behind the European legal stature in relation to the adoption and effective use of CCTV in public places.

There are other ethical issues related to CCTV surveillance such as the lack or reciprocal eyes that is the person being surveyed has no idea he/she is under surveillance and/or who is watching him/her through the CCTV system. Also with the implementation of smart CCTV systems that involve face detection, data will result in an increase of interest from unauthorised parties and thus increasing privacy issues.

Whether supporting or rejecting the idea of CCTV deployment, there is always a valid question to ask about the legality of such surveillance systems. Norris and Armstrong (1999) have presented a number of cases where the civil liberty of citizens have been ignored in favour of deployment of CCTV systems which have later proven to have been ineffective in crime reduction. Gill and Spriggs (2005), among many things, have also made a special reference to the issue of privacy and civil liberty in their comprehensive report of the UK CCTV systems. They have particularly referred to cases where the social costs arising from deployment of CCTV has significantly exceeded the social benefits.

Taylor (2010), whilst evaluating the entire surveillance systems in the UK, made a special reference to inhumane nature of CCTV in some parts of the country denying the basic human rights of individuals involved. In support of his evaluation, Taylor (2010: 229) makes a reference to the case of George Peck who was apparently filmed by CCTV having attempted to commit suicide by cutting his wrists with a knife. The footage of Mr Peck was used and released to two newspapers, and in a national television programme.

George Peck took his case to the European Court where the European Court of Human Rights found that his rights under Articles 8 and 13 had been violated.

Webster (2009) argues that crime reduction of CCTV should not be taken for granted. Moreover, he states that the rationale for, and evidence base behind, CCTV policy and practice need to be re-examined by all parties involved. In so doing, the study explores a policy perspective approach to understanding the CCTV revolution and its complex entangled interactions between government, policy-makers, the media and other stakeholders, and that CCTV does not necessarily have to 'work' if it meets other purposes. The article also presents evidence that CCTV policy is being reviewed, not just in relation to its established evidence base, but also in relation to the emergence of concerns raised about the cost of running systems.

Another smart CCTV feature, facial reconstruction, is based on images present an even bigger ethical concern. The system uses features acquired from low resolution frames to create an approximation of the face that may or may not be the original image. There have been cases where the case of mistaken identity by this system has produced tragic results, for example the tragic case of Jean Charles de Menezes (**Stockwell One: Investigation into the shooting of Jean Charles de Menezes at Stockwell underground station, 2007). In a similar case of mistaken identity by the CCTV system Senator Edward Kennedy was placed on a no fly list in the US, thereby preventing him from flying anywhere for several days.

When examining the possible social effects of the conventional and intelligent video surveillance systems, Held et al (2012) question where and when is it appropriate to deploy such cameras. On the issue of ethics, the study reports that unconcealed cameras tend to lead human behavior to be normalized as people would be aware that they were being watched and hence may refrain from going to prohibited areas or conducting obscene and inappropriate acts. Furthermore, on the issue of legality of smart CCTV, Held et al (2012) point to the fact that German courts have recently ruled out the human observation of surveillance footage leading to violation of privacy, and not the camera itself.

In the case of data protection Acts regarding CCTV, embedded in the Greek Constitution, Mitrou et al (2014) have stated that the right to security does not have a distinct and self-existent ground. They highlight that due to their historic experiences under dictatorship and non-democratic regimes, many Greek citizens have developed a negative state

monitoring culture. Similar focus and examination of data protection regarding privacy and security at the European wide law and regulations have been discussed in Hallinan (2014) and Porcedda (2014).

The main essence of any legal implication arising from the use of CCTV relates to the legal protection of the data (images and sounds) and its depositing. As has been examined in Pastukhov (2014), the identification of data streams generated by CCTV applications need to be further investigated and if possible deleted. Consequently, as this study suggests the issue is to do with the legal relevance of the so-called "de-identification" irreversibility in relation to technological and legal requirements that the irreversible de-identification may require.

More recently, Georgoulas (2013) strongly argues against the legitimation and validity of installation of CCTV in public places in curbing and deterring possible conflicts and criminal activities. Furthermore, Adams and Ferryman (2013) also argue about the question of legitimacy and legality of the use of CCTV without consulting the people involved. They propose that for any new plans involving deployment of further CCTV systems, the local government should contact and consult with individuals being constantly watched through the eyes of such cameras. Conducting such surveys, they believe, can give validity and legitimacy for the deployment of CCTV systems.

In an examination of a recent national survey of six U.S. States which use drones for surveillance purposes, Miethe et al. (2014) have concentrated on the views of the residents of Nevada State. The authors are of the belief that due to the presence of this type of technology in the State, and increasing media attention to drones, there is potential for Nevada residents to exhibit greater support for UAS (Unmanned Air Craft System) technology compared to national public attitudes. Based on a survey of 133 businesses and residents across different parts of Nevada, the survey suggests that, although nearly 75% of people are against the use of drones, Nevada residents are more supportive of aerial drone use for domestic surveillance across various contexts compared to the U.S. Population.

2.6 Cultural and Religious Issues

To date, very little research has been conducted in the areas of culture and religion as determinants of CCTV deployment. By considereingifferent technological and human characters, Cannataci (2009) makes an extensive reference to technology and CCTV as imparting information, privacy and freedom hence denying the basic human rights. He

also identifies areas where religious and cultural sensitivities need to be incorporated into the process of decision-making vis-à-vis deployment of new technically advanced CCTV technology.

Incorporating cultural values and psychological factors into their analysis, Budak and Rajh (2014) have measured the importance of these factors in the success of the CCTV deployment. They argue that the more people are made aware of the usefulness of the CCTV the lesser will be the adverse impact of culture and religious aspects on deployment of the surveillance systems.

From a psychosocial point of view, it is necessary to find out how individuals and the society can adapt to changes following the installation of CCTV surveillance systems. Hidalgo et al. (2014) have considered this issue in relation to the perception that people may have about the negative impact of CCTV on their lives. Based on a sample of 102 participants in Malaga, Spain, they report that over 60% of participants have declared feeling safer in the presence of CCTV surveillance systems. However, this seems to be at odds with similar cases in less crowded places in Spain. The study therefore attempts to point out to the fact that even in a given country, people's attitudes can change significantly depending on where they live and what they have been experiencing.

On personal values and perception, primarily based on the people's cultural values, van-Lieshout and Friedewald (2014) argue that although there appears to be a trade-off between perception about privacy and security, types and extent of fear can influence the CCTV installation. In short, it can be said that greater demand for security tends to overshadow the impact of personal or public perception about privacy and other cultural issues.

Said et al (2007), when considering the role of information technology in Saudi Arabia, have examined a large sample of Saudi citizens. The study agrees that the rate of acceptance of IT and other related facilities is rather low in Saudi Arabia primarily due to some mix of cultural and religious issues. Alhadar and McCahill (2011) state that resistance to deployment of CCTV systems in Saudi Arabia is primarily due to religious and cultural backgrounds. However, their study show that the new surveillance technologies used as a pilot case has not only saved businesses against theft, but also has managed to protect public morality; hence arguing in favour of further deployment of such facilities in the kingdom. Similar issues relating to female teachers in Saudi Arabia have been raised in Jamjoon (2010), highlighting the social, cultural and religious

pressures imposed on women in adopting and acting liberally towards advancement of technology.

To investigate the socio-cultural origins and the patterns of technological innovation, Coccia (2013) has made an analytical approach and taken a large dataset of countries based on level of technical innovation and acceptance, their religious backgrounds and their GDP growth rates. The estimated findings are indicative of the fact that in developed economies with grater religious plurality (a proxy of cultural diversity) tend to enjoy more sustainable growth rates and attract more innovative technologies. On the whole, Coccia (2013) concludes that societies with a predominance of the Protestant, Jewish and Confucius religions tend to perform better in technological innovation and technical acceptance than societies with other predominant religious cultures.

To highlight the extent of severity of cultural and religious factors in shaping the Saudi society, Al-Lily (2011) has made references to a number of cultural factors relating to a female's life. References have also been made by Al-Lily to the development of technology and communication means in creating some problematic issues in the country. In particular, the study highlights the problem of face recognition and other means of identification facing the CCTV control room operators. Al-Lily (2011) is of the belief that in the future when more of such communication and surveillance means are introduced, then the conservatism and protectionism of women will be loosened, giving the way for more effective implementation of new technology.

2.7. Evaluation: CCTV Surveillance systems in Saudi Arabia

Saudi Arabia has witnessed a massive improvement in economic development in the past 30 years with profound progress in computer technology, health sector, education, housing and environment (WHO, 2007). There are now extensive networks of roads, highways, motorways, airports, seaports, power plants, and huge industrial complexes. Saudi Arabia is an Islamic Kingdom where strict Sharia Law is enforced on all public and private governance.

With this rapid development in all sectors it is very important to protect these premises and the most effective technology can be CCTV surveillance technology. An examination of the effectiveness and social costs and benefits of CCTV deployment in other countries can offer insights into such development, however, in Saudi Arabia, religious, cultural and traditional values need to be seriously considered before large-scale CCTV systems are deployed. According to Swainston (2013) the Ministry of Education in Saudi Arabia

has announced that CCTV camera systems are to be installed in around 33,000 schools around the Kingdom in order to protect students. The main aim of such initiative is to promote the culture of safety and security among teachers and students along with private security personnel that could be used to enforce safety regulations (Swainston, 2013). Further, there are 5 million students and 700,000 teachers who are actively involved in their duties and if these steps were successful would mean one third of Saudi students' and teachers' personal safety and security would be greatly improved.

Therefore, a serious need for the deployment of CCTV Surveillance systems in Saudi Arabia and its booming industry and infrastructure is desired. However, strict Islamic laws can prevent its full deployment because in Islamic laws women or men cannot take picture/video or acquired picture/video. Therefore, it is very hard to make the case for the deployment of CCTV systems. With the government recent initiative, as discussed above, by installing CCTV cameras in 33,000 schools around the kingdom will provide better initiative steps for CCTV future in Saudi Arabia. CCTV System will help to ensure the physical and operational security around Saudi Arabia business, commercial and housing areas. It will protect people, properties, and processes.

Regardless of all these cultural and religious tensions, both the cost and the number of CCTVs have grown significantly in all GCC countries, with Saudi Arabia having the highest share of such expenditure (MEED, 2014). It is estimated that spending on surveillance solutions, equipment, software, design and installation services, across the GCC states could exceed $4.0bn or an average of $1.0bn annually. It must be kept in mind that these estimates do not include retrofit investments such as the multi-million dollar project being initiated by Saudi Arabia‘s GACA (General Authority of Civil Aviation) to upgrade the security and surveillance infrastructure at the kingdom's domestic and international airports (MEED, 2014).

One of the earliest forms of CCTV surveillance systems in Saudi Arabia was erected in major motorways and highways aiming to safeguard the drivers and to enable easy flows of traffic. This system is primarily based on the previous research particularly that of Khalil (2010) on car plate recognition. This system has been improved on yearly basis across the country, and currently it enjoys state-of-the-art systems which control and detect speed, traffic composition, vehicle shapes and types, number plate identification and all occurrences of traffic violation or road accidents (Kurdi, 2013).

The application and deployment of an electronic system to combat drifting and traffic noise on busy Saudi roads has been promoted in Dhaou (2012). This system is made of a sound processing hardware, a CCTV camera and a satellite navigation module for wireless IP access. An algorithm for addressing noise drifting and accidents is derived in this paper and then conducted a test over a range of distinct traffic noises in a small town in Saudi Arabia as a pilot study. Dhaou (2012) concludes by stating that the overall findings from the research indicate that the algorithm produces no false alarm.

To promote the deployment of the so-called the distributed multimedia surveillance systems in both public and private places in Saudi Arabia, Rahman et al (2014) explained that such systems would utilise heterogeneous sensors like cameras, motion sensors, sound sensors and RFID in providing safety and security for all. In their paper, they applied a holistic approach to identify any externalities in relation to different privacy channels to conceal privacy-sensitive data obtained from distributed visual sensors. In furnishing the privacy issues arising from the use of this system, the research has provided the privacy-leakage attack model as well as the security analysis of their proposed solution.

One of the most controversial and heated CCTV surveillance installation projects in Saudi Arabia was related to monitoring the density of pilgrims during the annual Hajj in Makkah. In the end, the government won the case against the opposition by installing a sophisticated surveillance system, built by France's Thales, designed to prevent accidents and stampedes when pilgrims cross over the Jamaraat Bridge, where fatal crushes had previously and almost every year occurred and led to several fatalities and serious injuries (MEED, 2014).

Tried and tested on Hajj pilgrims in Saudi Arabia, Dridi (2014) has come up with the model for tracking individual targets in high density crowd scenes where thousands of people are gathered. The system provides a real-time method for pedestrian recognition and tracking in sequences of high resolution images taken by cameras located in different places in the Haram mosque in Makkah, with the aim of estimating pedestrian movements and speed as a function of the local density. The tracking method is superior to the earlier versions in that it uses a virtual camera which is matched in position, rotation and focal length to the original camera of the 3D-model. By combining all these variables with the available appearance information, the research claims that the system is able to track individual targets in high density crowds. Similar simulation and testing has been

conducted in Sakellariou et al. (2014) based on the Makkah a crowd control CCTV surveillance system.

However, in consideration of case studies of CCTV effectiveness in a number of US and European countries, most evaluative investigations have led to unclear and inconsistent verdicts (Phillips, 2001; Gill & Spraggs, 2005; Lepon and Popkin, 2007; Taylor, 2010). In short, however, as has been suggested by most researchers, the question of potential effectiveness of CCTV systems should be considered in association with a large number of social, economic, legal, cultural and religious factors shaping our modern life (Piza, 2012).

On the basis of recent security scare in the region and at the same time increasing number of construction and petroleum related projects, it is anticipated that the region in general and Saudi Arabia in particular would witness more CCTVs in most strategic areas. This is in spite of the recent opposition and resistance to further deployment of CCTV in the country. In particular, in a number of regions in KSA, opposition to CCTV systems has been demonstrated in more violent manner where CCTVs have been smashed or severely damaged. In short, as has been discussed earlier, security issues and concerns have seriously overshadowed the other social, political and cultural factors in Saudi Arabia, having led to significant growth of CCTV deployment in the country. In short, in the light of such instability and insecurity measures, the society in Saudi Arabia, like anywhere else in the world, are gradually accepting the fact that CCTV surveillance is here to stay (Esposti et al., 2014; De Pauw and Vermeersch, 2014; Patil, 2014).

2.8 Summary

This chapter has made an extensive attempt to critically identify and analyse the related works that have been conducted previously in this area of study and understand and justify the application of CCTV system in protecting peoples' lives and properties. Therefore, in line with the aims, objectives and questions of the thesis, the chapter has addressed the most significant pros and cons arising from the deployment of CCTV system in Saudi Arabia, using other nations' experiences. In doing so, references are made to legal, cultural, religious, traditional and technological issues surrounding deployment of CCTV systems in Saudi Arabia.

The examination of the CCTV surveillance systems in the Western countries has demonstrated that the legal aspects associated with the implementation and use of CCTV have been identified as the most important hurdles. Furthermore, the advancement of

technology and introduction of new innovative techniques have brought efficiency and security to the public at large.

As for the developing countries, it has been demonstrated that cultural factors have been the major determinants of slow development of CCTV systems. The chapter has made an specific reference to the case of CCTV deployment in Saudi Arabia and has argues that strict Islamic laws has prevented its full deployment because in Islamic laws women or men cannot take picture/video or acquired picture/video. Therefore, it is very hard to make the case for the deployment of CCTV systems. Nevertheless, as has been discussed earlier, in recent years as security issues and concerns have severely overshadowed the other social, political and cultural factors in Saudi Arabia, more significant growth of CCTV deployment in the country has been observed.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction:

This chapter aims to examine and provide a rationale for the choice of research methodology and design, which are to be adopted throughout this research. Moreover, this chapter is to describe the processes utilised when gathering and subsequently analysing the data.

Briefly speaking, by methodology one refers to "how research should be undertaken, including the theoretical and philosophical assumptions upon which research is based and the implications of these for the method or methods adopted" (Saunders et al., 2007: 481). Similarly, Crotty (2005: 3) refers to methodology as "the strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes". Furthermore, Mingers & Brocklesby (1997) state that methodology represents a set of clear guidelines aimed to assist researchers in undertaking their studies. Therefore, methodology is concerned with the general process of the study, ranging from the general theoretical foundation through to data collection and collation and the final analysis (Collis & Hussey, 2013).

To determine the most appropriate research methodology, it is advisable to revisit the aims, objectives and main questions of the study (Partington, 2002). This task has been presented in part 2. Part 3 is devoted to the detailed analysis of research philosophy aiming to identify and correctly justify an appropriate research theoretical framework. Once the research philosophy has been identified, one should search for the appropriate research approach, strategy and research design which are presented in parts 4, 5 and 6, respectively.

3.2 Research Strategy

The choice and the process of undertaking research represent the research strategy and is seen can be seen as one of the most important parts of any study. Generally, this depends on the aims, objectives and the research questions of the investigation. Whether adopting a deductive or an inductive approach, the research is then faced with the question of how

to do it. If a deductive approach has been undertaken, the researcher is expected to employ experimental or survey strategies. On the other hand, when adopting an inductive approach the researcher is expected to employ the strategies of case study, grounded theory and action research (Hair et al, 2003). On the basis of the study's questions and objectives, a survey approach is to be carried out. The rationale for the choice of survey strategy can be summarised as follows:

• The survey method is usually associated with the deductive approach as it is the most appropriate used strategy in this study.

• This is the most appropriate strategy when data is to be collected from a sizeable sample of population at a particular time (Leedy & Ormrod, 2005). This is because a large sample size would lead to unbiased estimates for the model under investigation.

• Survey-based research (quantitative approach) seeks to identify relationships that are common across users, organisations and, therefore, provide a general statement of the theme/topic being researched (Eldabi et al., 2002).

3.3 The Research Philosophy

As has been elaborated in Healy and Perry (2000), a scientific research paradigm must be treated as an overall conceptual framework within which researchers work. Fossey et al. (2002:718) have defined it in a much wider scope as a set of interrelated "assumptions about the world which is shared by a community of scientists investigating the world". Undoubtedly, the choice of research philosophy is one of the most fundamental aspects to be considered by researchers when seeking to answer the research objective (Collis & Hussey, 2009). According to Easterby-Smith et al. (2002) research philosophy not only helps determine the study design, it provides us with the ability to establish the most appropriate study design; and subsequently creating a study design outside the researcher's prior experience.

According to the literature, there are two main research philosophies or paradigms dominant in the research context: positivist and interpretive/phenomenological (Collis and Hussey, 2013; Malhotra and Birks, 2007; Mallet, 2007). Philosophy, therefore, forms a critical issue as it shapes the way in which the whole research is designed and through which knowledge is gained (Saunders et al, 2007). Whilst a positivist research is normally associated with quantitative investigation, an interpretive study usually involves qualitative and descriptive research (Johnson & Onwuegbuzie, 2004). In the words of Collis & Hussey (2013), a positivist paradigm originates from natural sciences and

primarily rests on the *"assumption that social reality is singular and objective, and is not affected by the act of investigating it"*. Therefore, in the light of this definition, positivism is supposed to be based on observable social realities, which are examined by means of quantifiable measures. In short, positivism must be regarded as a philosophy based on the creation of knowledge through research with the emphasis on development and examination of models based on a chain of causality (Noor, 2008). In short, positivist paradigm offers the following five characteristics: (i) it is deductive (theory based); (ii) it seeks to identify and explain causal relationships; (iii) it uses quantitative data; (iv) it usually tests hypotheses; (v) it employs methods and models for the purpose of replication and forecasting.

The interpretivism, on the other hand, is a paradigm that rests on the assumption that social reality is, in the main, subjective and multiple. The interpretive researcher, therefore, attaches significantly much less weight on generalizability; hence usually involves in describing and making interpretations about observations (Saunders et al, 2003). Consequently, such researchers employ an inductive approach in dealing with their observations, rather than fitting such observations in a theoretical framework (Collis & Hussey, 2013). In other words, it can be said that a phenomenological paradigm aims to focus on and to attach the research subject's meanings to social phenomena (Al-Khattab, 2011). This is to say that phenomenological paradigm assumes that any given phenomenon will happen regardless of who is observing and interpreting it. It is therefore fair to argue that phenomenological researchers attempt to understand what is to happen and why, and this is the way people normally view different experiences, rather than searching for an established theory or for causes to explain behaviours (Leedy & Ormrod, 2005).

Based on this debate, it should be argued that the method of investigation in this study is a mixed approach resting on both qualitative and quantitative methods. Therefore, the rationale behind choosing a multi method approach for research can be summarised as follows:

• The multi-method of data collection enables triangulation to take place (Leedy & Ormrod, 2005). Triangulation, as has been defined by Saunders et al. (2007), is the use of two or more independent sources of data collection methods within a given study, ensuring that data collected from one source checks and balances with data collected from another source.

• The choice of multi-method data collection follows directly from the research questions; where the first and the third questions of the thesis are qualitative by nature, the second question in inherently quantitative.

• Use of multi-method (questionnaires and interviews) in this research due to the lack of availability of high-quality published database; hence the collected data from our case studies can be of use to other researchers and decision makers alike.

• The combination of the questionnaire survey and use of relevant quantitative techniques can provide a significant contribution to clarify and comprehend the real essence of issues arising from the use of CCTV.

3.4 The Research Approach

As discussed earlier, there are two general approaches to conducting research work: deductive, and inductive (Mangan, 2004; Saunders *et al*., 2007). These approaches are designed to offer an indication of the overall nature of any possible link between the research and its underpinning theory (Bryaman, 2004). In the view of Saunders *et al*. (2003), it is also acknowledged that both of these approaches are linked with a number of different philosophies, i.e. deductive is related to positivism, and inductive to phenomenology.

According to the deductive approach, researchers deduce their studies' hypotheses based on some known facts or theories, and then translate them into operational terms for testing by the use of statistical methods (Bryaman, 2004, Sunders et al, 2007). The inductive approach, on the other hand, starts from a set of observations to build a theory. In effect, a theory is introduced by making a number of general suggestions concerning what has been observed during a particular timescale, and their nature (Anderson, 2004).

Therefore, deductive research starts with existing theories and concepts, and formulates hypotheses that are later tested with the help of empirical data. On the other hand, inductive research starts with the empirical data, and the result is the emergence of concepts, models, and eventually theories (Clough and Nutbrown, 2012; Gerring, 2011). Furthermore, it is also recognised that the deductive approach is built on the meaning established from the data analysis through rational generalisation of a known fact; on the other hand, when conducting an inductive approach, emphasis is instead directed towards general suggestions in consideration of known facts (Arthur, 2012). On the basis of what has been stated, this research is therefore mainly deductive despite being based on triangulation methods of primary data collection.

3.5 Research Design

Once the research strategy has been identified, the next step is how to implement it. The process of implementation of the strategy is referred to as research design which can be viewed as a combination of various chosen approaches for carrying out the study in an attempt to reach the most appropriate outcome (Churchill and Brown, 2004; Saunders et al., 2009). Undoubtedly, decisions on the design of research is highly crucial, as it can have a significant impact on the entire study, as it provides a detailed overview of how the study should be guided and directed (Collis & Hussey, 2009). Establishing the study design can be viewed as the development of a detailed plan, helping the investigator to identify the most appropriate methodology of the study. As has been highlighted in Saunders et al. (2009), research design is all about a plan which highlights how the research objectives can be achieved.

Creswell (2003) has recommended that researchers should select the study design during the initial phases of the study, as the design will enable one to establish a number of other important elements, including the methodology, data collection methods, and data analysis techniques. Kumar (2014), on the other hand, state that the research design process should be periodically reviewed to overcome any new developments in theoretical structure and the study questions. On the basis of what has already been discussed earlier, the research relies on the development of a questionnaire to be completed by customers and employees of a number of businesses; and a series of semi-structured interviews, and then proceeding with the use of appropriate methods of investigation. In short, the design of the research is one of a survey, for which the data and other information is collected through questionnaire and interviews.

On the basis of the above, the overall structure of the study's methodology can be shown as chart 1. As this chart depicts, the overall analysis of the thesis is based on the contributions made through findings from the questionnaire and the interviews.

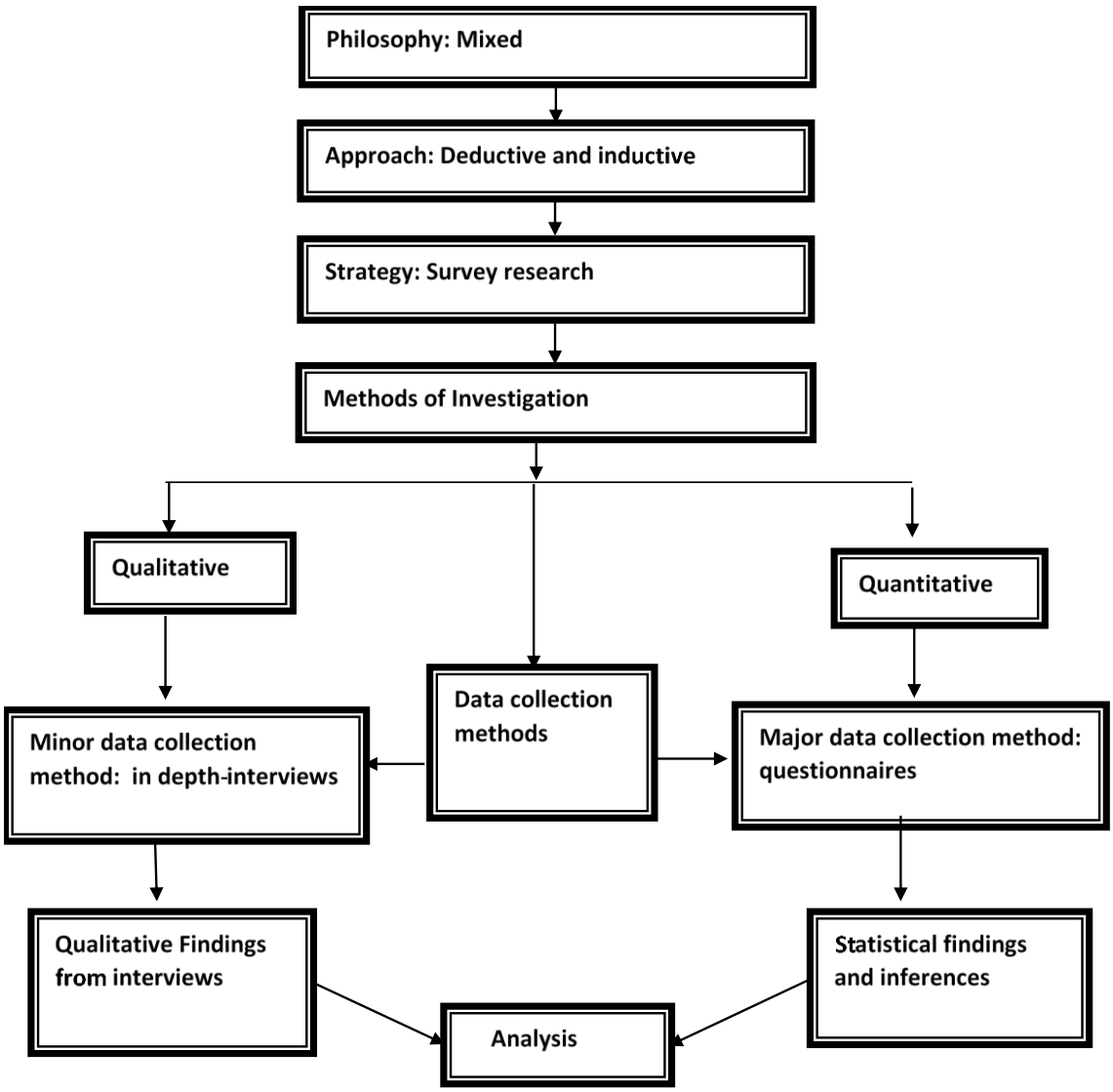


Figure 0.1 Structure of Methodology

3.6 Data Collection Method: Questionnaires

Methods of data gathering are a fundamental consideration in such an investigation. The appropriate selection of data collection methods enables the investigators to achieve the objectives of the study (Leedy & Ormrod 2001). Questionnaires, observations and interviews are the three main data collection methods used in survey research (Bryman, 2015). They can be utilised for the purpose of testing hypotheses and providing descriptions and explanations (Arthur, 2012). However, interviews and questionnaires are

utilised most commonly through surveys (Easterby-Smith *et al.*, 2002). Accordingly, both of these methods are discussed in further detail in the subsequent sections.

The questionnaire approach is considered as particularly useful when seeking to collect data relating to the opinions, expectations or perceptions of a large sample group in regard to specific phenomena (Collis & Hussey, 2009). As has been advocated in Remenyi *et al*. (2005), the overall aim of a questionnaire is to gather data which cannot otherwise be observed. The resulting information would then be utilised in order to provide descriptions, analyses, and hypothesis-testing. Nevertheless, there are usually various issues which can emerge during the implementation of the questionnaires including the need to ensure effective responses, the need for unbiased sampling, and the need to ensure a high response rate. Consequently, it can be argued that all the three aforementioned issues are linked with the key advantages and disadvantages of questionnaire utilisation (Gillham, 2008). It must be stated that the benefits associated with this type of method lies in its efficiency in terms of time-efficient and inexpensive data collection (Sekaran, 2003).

In the light what have been stated above, the research aims to adopt a mix approach embarking on both questionnaire and interview methods, in order that more comprehensive and conclusive findings to achieve.

Administering Questionnaire: Once a questionnaire has been designed and developed then the next question is how it can be utilised d in terms of the ways in which it is carried out, i.e. interviewer-administered or self-administered. In the case of the former, these may involve telephone questionnaires and structured interviews, which the interviewer may decide should be recorded so as to facilitate data analysis later on in the research process. One main drawback of interviewer-administered questionnaire is the difficulty in finding a suitable time for respondents. As for the self-administered questionnaire, it is usually carried out by the target sample, where the questionnaire is distributed and returned via electronic means, such as e-mail. Furthermore, self-administered questionnaires may also be posted to respondents. In the light of our survey of customers and staff in Saudi Arabia, the study aims to conduct a self-administered method of data collection, for its efficiency and time-saving features. A potential problem with this method is associated with generally low response rates. This method is also suitable in

the Saudi context because the mail system is not effective enough to send postal questionnaire to the companies sampled.

Population and Sampling Issues: After defining the population, it is necessary to identify an appropriate sample and a suitable sampling frame. As has been reiterated in Collis and Hussey (2013), selecting a sample is a fundamental element of a positivistic study, and that there are several compelling reasons for sampling, including reduced costs, improved result accuracy, faster data collection and ease of population selection (Chisnall ,2005; Cooper and Schindler, 2006; and Malhotra and Birks; 2007). A representative sample should be large enough to satisfy the needs of the study and should be chosen randomly to reduce chances of biasedness (Collis & Hussey, 2013).

The two main techniques of choosing a sample are random (probabilistic) and non-random (non-probabilistic), where the former refers to a sample potentially representing every segment of the population while the latter refers to a sample based on a pre-selection of the population, primarily based on the researcher's judgement (Leedy & Ormrod, 2010: 203).

In this study, based on three case studies (two hospitals and one private business), we intend to conduct a stratified sampling approach of staff and customers/patients. This study has distributed 200 questionnaires to patients of the two hospitals to customers of the private business. However, the final completed questionnaires reached 75. In addition, special questionnaire designed for the staff working in these three organisations. Of 120 questionnaire distributed, only 75 were used as fully completed.

In this study, based on three case studies (two hospitals and one private business), we intend to conduct a stratified sampling approach of staff and customers/patients. It is anticipated that up to 200 questionnaires to be distributed to patients from the two hospitals and 50 to customers of the private business.

Questionnaire Design: In order to achieve the aims of the questionnaire, several basic issues should be considered, as a well-designed questionnaire can make the tasks of both participants and researcher easier and reduces errors (DeVaus, 2002). First and foremost, the questionnaire must be designed in the way that it would deal with the questions of research. Secondly, the questions in the questionnaire should be written with good flow

to be easier to read, understand and respond (Mangipne, 1995). Thirdly, in order to receive good feedback and guidelines in respect of questionnaire design and redesign, a pilot study should be conducted (Oppenheim, 2000).

One area where answers to the questions are easily registered and quantified is to adopt a five-point or seven-point rating scales, preferably the Likert scale. A five-point scale is regarded as a 'balanced scale' since the number of positive and negative categories is equal (Hair et al., 2003). The main rationales for using a Likert scale are as follows:

a) it helps respondents to make good judgements as it provides them with some degree of flexibility of choice to reflect the intensity of respondents' views;

b) it does not confuse the respondents with having many choices and makes them comfortable with a wide range of choices on its continuum scale and that it is easy for respondents to complete; and

c) it allows the researcher to employ a proper coding scale and conduct several statistical techniques with the collected data.

Statistical Techniques and Inferences: Once the data has been collected and collated from the questionnaire, the next task is what to do with it. Apart from the use of basic statistical inference such as mean values, percentages, standard deviation and correlation matrix, given the nature of the study, one should go further to test the statistical validity of the deterministic factors. In so doing, one needs to apply a certain number of regression analyses (simple linear regression, factor analysis, simultaneous system of equations) in order to estimate the extent of contributions that deterministic factors make to the use of CCTV systems in Saudi Arabia.

A factor analysis as opposed to a simple linear regression is used when the number of potential explanatory variables exceeds the requirement for statistical consistency. In this case, the technique aims to include the explanatory variables which represent the much greater variation in the dependent variable (MacCallum & Austin, 2000). Recently, though, the so-called structural equations system (SES) has emerged where the measurement model is a multivariate regression model that describes the relationships between a set of observed dependent variable and a set of continuous latent variables. The structural model part considers three types of relationships in one set of multivariate regression equations: i) the relationships among factors, ii) the relationships among observed variables, and iii) the relationship between factors and observed variables that are not factor indicators.

Questionnaire Target: The subjects of questionnaires are two groups: the user of CCTV and the subjects under surveillance. The questionnaire is to be divided into two parts where the first part will be designed for customer (e.g. patient, seller, etc.) and the second part will be targeted toward staff and management team (e.g. worker, clerk, managers, stakeholders, etc.). This will help understand the concerns that both entities exhibit in relation to new surveillance technologies. For the former one, the questionnaire can be about effectiveness, coverage, cost and purpose. For the later one, privacy, culture, economic benefits and social engineering will be considered. This will help understand about the Saudi people psychological/social effects, their concerns about CCTV systems and how to defuse the effect in general. Further, the research will investigate the effects of counter-surveillance, inverse surveillance, and other controversy about CCTV surveillance systems in Saudi Arabia.

3.7 Data Collection Method: Interview

In qualitative studies, interviews are viewed as being the most important of data collection approaches (Yin, 2009). As Knight (2002) has argued, the more data sources are investigated and the greater the number of data collection methods used, the more accurate and certain the research findings will be. In addition, Bryman & Bell (2007) and Sekaran (2003) argued that in some studies, qualitative data is used to corroborate quantitative findings.

Using qualitative data following quantitative research is deemed to help to support and probe quantitative findings; and that one effective way of achieving this is by the means of interviews. Collis & Hussey (2013) defined an interview as a method of "collecting data in which participants are asked questions in order to find out what they do, think or feel". This technique can be adopted whether the research uses a positivist or phenomenological approach. In this research the semi-structured interview technique was selected for the following reasons:

(i) Semi-structured interviews have the highest degree of flexibility of all qualitative methods and are able to reach specified subjects more effectively than the questionnaire method (Leedy and Ormrod, 2005).

(ii) Semi-structured interviews allow the researcher to ask more complex questions and to ask follow-up questions not possible in the questionnaire. Moreover, it takes into account the non-verbal communication such as the feeling, behaviour, attitudes and facial

expression of the interviewee. Thus, it may allow a higher degree of confidence in the replies than in the questionnaire responses (Hussey & Hussey, 2003).

(iii) The use of the interviews increases the certainty of information collection, as it allows the researcher to explain the purpose of the study more freely and to clarify any doubt or to avoid misunderstanding of the questions or concepts (Oppenheim, 2000).

In this study, within our defined case studies, a series of interviews from experts and IT technicians will be taken in order to understand and evaluate their views about the CCTV surveillance system use and enhancement.

3.8 Case Studies

In this study, three cases studies are selected: two Medical Centre Hospitals in Riyadh; and Alfardan Jewellery. The choice of these three cases is based on two main reasons. First, the cases cover both public and private domains in Saudi Arabia; hence providing an opportunity of comparing the two sectors' views and use of CCTV surveillance systems. Secondly, both establishments are large enough to provide us with required sample size for statistical analysis.

As for the hospitals, their vision statements are clearly based on gaining public trust and maintaining high health care standards (SMC, 2013). The larger hospital – Specialised Medical Centre - employs around 300 full time physicians and 1,600 paramedical and support staff with thousands of patients visiting every day (SMC, 2014). Further, this hospital consisting over 450 inpatient beds and over 140 outpatient clinics is served by dedicated and highly qualified team. Unfortunately, there is yet no CCTV surveillance system installed in their premise. Despite the presence of a large number of security guards on different floors and important areas, full security cannot be maintained without the use of CCTV surveillance system. Therefore, choosing this hospital as a case study would help the research to make a strong case where the necessary application of technology has been denied at the expense of cultural and traditional values. The research will also be focused on what cultural and trust issues make it difficult to utilise CCTV systems. The other hospital, Al-Qasimi, is one of the most technologically advanced medical centres in the region with branches in three GCC states. In their Riyadh branch, the Al-Qasimi hospital employs around 150 full time physicians around 700 paramedical and support staff, serving around 1000 patients a day.

The third case study, Alfardan Jewellery, is one of the biggest businesses in Saudi Arabia with several branches across the country. However, in a recent investigation, it has been

found that CCTV surveillance systems installed in this business is yet very limited. The cameras are installed in few areas such as on doors and around the buildings but not inside the stores, warehouses or offices. The jewellery can be worth millions of Saudi Riyals and it is important to install CCTV systems especially in stores where customers mostly visit and warehouses where all the stock is in place. In this case study, it is expected to find main causes that prevent the business from installing the visual surveillance systems in these important sites. Further, the examination of this case will tell us what benefits businesses will get from installing CCTV system in comparison with the similar businesses in the world

3.10 Ethical Considerations

In any survey approach consideration of ethics is an important element of the research study. For example, questionnaires completed by staff or interviews of senior members and experts should be regarded as sensitive information and many respondents are therefore directly affected by the changes to the business. It is important to make sure that both the research methodology and the outcome of the investigation do not breach any ethical boundaries. According to Coghlan and Brannick (2001: 73), there is a comprehensive list of ethical issues that researchers need to follow strictly to ensure being true to the process:

I. negotiating access with authorities and participants;

II. ensuring confidentiality of information, identity and data;

III. ensuring participants the right not to participate in the research;

IV. getting permission to use documentation for other purposes;

V. maintaining one’s own intellectual property rights;

VI. keeping good faith by showing that you can be trusted;

VII. agreeing on how to publish descriptions of their work and of view.

The protocol for this research has been approved by the Ethics Committee at the University of Northumbria where the researcher is conducting his doctoral research. The respondents' names will be "Completely Anonymous" and the responses will be treated as "Strictly Confidential". The data will not be kept longer than necessary to complete this research study and publishing academic papers, and no company or individual will be contacted as a result of the information respondents provide.

3.11 Summary

In search for an appropriate approach to use for this research the chapter has reviewed a number of methodological methods and procedures applicable to the theme of the study. The examination of the research philosophy demonstrated that the current research is a mix of inductive and deductive as it could partly be based on theoretical framework. As for the strategy, it became evident that in order to be in a position to collect appropriate information one needs to approach a mixed method of data collection. The research therefore resorts to collecting data from both a questionnaire and a number of interviews.

CHAPTER 4: ANALYSIS OF THE FINDINGS

4.1 Introduction

On the basis of the framework set out in the methodology chapter and in relation with the aim and objectives of the study, the three different questionnaires were designed and distributed to customers/patients, staff and CCTV controllers in the three places (SMC and HMC hospitals and Alfardan Jewellery). The process of initial provision of information to participants about the nature of the study and guidelines in completing questionnaires were followed in line with the procedures explained in the methodology chapter. Furthermore, a number of structured questions were set for the purpose of interviews of the stakeholders in regard CCTV systems.

As explained earlier, both the questionnaires and the interviews were designed and conducted in order to identify the extent of several issues relating to CCTV surveillance presence, prevalence, use and monitoring. In this respect, three groups of participants were targeted: customers/patients, staff, and controllers of CCTV systems. The customers of Alfardan jewellery and patients from the two hospitals (SMC and HMC) are to be examined separately at the first instance, but they will be merged later on for further statistical purposes. Due to small samples of staff at each organisation, the responses of all the staff in these three organisations will be pooled together to generate a larger and more reliable sample size. Finally, the responses received from the CCTV controllers in each organisation will be examined separately. For interviews, again the three groups (patients/customers, general staff, control room staff) were asked three different sets of questions.

The rest of this chapter is structured as follows. Section 2 presents the analysis relating to the questionnaires by examining some general characteristics of the participants (customers/patients, general staff, control room staff) including an examination of relevant responses through use of statistical inferences, aiming to identify similarities and differences among participants in relation to their views about CCTV surveillance systems, and the development and application of a logistic model for explaining the relationships between constructs shaping support for or rejection of installation and

monitoring of CCTV cameras. Section 3 examines the findings from the interviews. Finally, part 4 provides a summary and some concluding remarks.

4.2. Pilot Study

As discussed earlier, prior to undertaking the final presentation and distribution of the questionnaire to participants, it is highly recommended that a pilot study to be carried out. The main advantage of the pilot study is to gather as much information as possible from a small subset of the target sample, primarily aimed to improve the presentation and delivery of the questions in the questionnaire.

Table 4.1 Selected characteristics of and responses by Customers: Alfardan Jewellery

Characteristic/Response		**Customers**	**Percent**
Gender:	Male	15	71.4
	Female	6	28.6
Educations Qualifications:	High School	7	33.3
	Intermediate	9	42.8
	Undergraduate	3	14.3
	Postgraduate	2	9.6
General Knowledge of CCTV:	No knowledge	5	23.7
	Little knowledge	11	52.4
	Enough knowledge	2	9.6
	Full knowledge	3	14.3
Perception on CCTV reliability:	Highly unreliable	5	23.7
	Unreliable	6	28.6
	Reliable	9	42.8
	Highly reliable	1	4.9
Perception on CCTV crime reduction:	Strongly agree	9	42.8
	Agree	3	14.3
	No opinion	6	28.6
	Strongly disagree	2	9.6
	Disagree	1	4.9
CCTV invading of privacy :	Yes	18	85.7
	No	3	14.3
CCTV protecting against intruders:	Yes	12	57.2
	No	9	42.8

Table 4.2 Selected characteristics of and responses by staff: Alfardan Jewellery

Characteristic/Response		**Customers**	**Percent**
Gender:	Male	16	88.9
	Female	2	11.1
Educations Qualifications:	High School	2	11.1
	Intermediate	13	72.2
	Undergraduate	2	11.1
	Postgraduate	1	5.6
Work experience:	1-2 years	9	50.0
	3-5 years	6	33.3
	6-8 years	2	11.1
	Above 8 years	1	5.6
Perception on CCTV reduction of theft:	Yes	13	72.2
	No	5	27.8
Perception on CCTV improving work:	Strongly agree	9	50.0
	Agree	6	33.3
	No opinion	2	11.1
	Disagree	1	5.6
	Strongly disagree	0	0.0
Perception on CCTV reducing work incidents:	Strongly agree	1	5.6
	Agree	1	5.6
	No opinion	2	11.1
	Disagree	5	27.8
	Strongly disagree	9	50.0

The pilot study carried out is based on small samples of customers and staff of the Alfardan Jewellery in Riyadh. Based on a customer sample size of 21 and staff sample size of 18, the following main information are presented in tables 4.1 and 4.2, respectively.

A summary analysis of the customers' responses in table 4.1 suggests that over 75% of such customers have either no idea or very little knowledge of CCTV and its applications. This has meant that they are not quite sure about the reliability of the surveillance systems as they are almost equally divided on this issue. Nevertheless, they are of the belief that CCTV can reduce crime and protect them against intruders. On the other hand, they are strongly (85%) unhappy and uncomfortable with CCTV invading their privacy. These findings, though limited in sample size and variety of questions, tend to relay an important message that most customers or people in general have very little information about the potential usefulness of CCTV systems. It is therefore the duty of the government and businesses to attempt to educate people about the potential uses and security implications of CCTV surveillance systems; hence overcoming some of the Saudi traditional fallacies about CCTV systems.

A summary of a pilot study based on the three cases offered in this chapter which helped the researcher to establish a correct and efficient ways of designing, implementing and collecting the relevant data for the study. Furthermore, the chapter ended with presenting a number of useful information relating to characteristics of the participants of the questionnaire.

4.2 Analysis of Questionnaires

4.2.1 Summary of Characteristics of Participants and Technology

In evaluating the participants' perception about CCTV surveillance, it is appropriate here to pay attention to a number of characteristics defining their socio-economic background, awareness, concerns and knowledge about CCTV. Since questions relating to incomes and the extent of religious beliefs and backgrounds tend to be sensitive issues in Saudi Arabia, the questionnaire has, therefore, been designed to consider education backgrounds and qualifications as a proxy for socio-economic stances of participants.

4.2.2 Customers/Patients Characteristics

Table 1 presents a summary of all the main characteristics of the customers and patients of the three institutions. As stated in the methodology chapter, it was the initial intention of the researcher to collect a sample of over 100 from the three institutions together. However, by the end of completion date, a total of 75 were collected, giving response rates of 83%, 62% and 83% for Alfardan, HMC and SMC, respectively. As the table shows, most of the participants were male, mainly due to their availability at the times of questionnaire distribution.

As for educational qualifications, as a proxy for socio-economic backgrounds, a massive variation was found in each establishment's clients. Although a large majority of participants declared that they had intermediate (High School Diploma) qualification, 20% of participants in SMC and 16% in HMC had no qualifications at all. However, between 12 and 16 present of customers/patients in these establishments declared to have a first degree. Although only 4% of patients in SMC had postgraduate degree, there were 12% of such patients in HMC, and 20% postgraduates in Alfardan.

Finally, in discovering the participants understanding, knowledge and usefulness of CCTV systems, a large majority (around 85%) of all participants in these establishments had either none or very little idea about CCTV. It is to be noted that those who declared that they had either a considerable or full knowledge of CCTV stood in the region of 12% to 17%.

Table 0.3 Main Characteristics of Customers/Patients in Alfardan, HMC and SMC

CHARACTERISTICS	Alfardan	HMC	SMC
Questionnaire Distributed	30	40	30
Questionnaire Collected	25	25	25
Response Rate (%)	83.0	62.0	83.0
Male (%)	72.0	60.0	72.0
Female (%)	28.0	40.0	28.0
Qualifications (%)			
None	20.0	16.0	20.0
Intermediate	52.0	56.0	64.0
Graduate	12.0	16.0	12.0

Postgraduate	16.0	12.0	4.0
Knowledge of CCTV			
None	12.0	36.0	32.0
Little	56.0	52.0	56.0
Considerable	12.0	12.0	8.0
Full	20.0	0.0	4.0

4.3.3 Staff/Managers and Controllers Characteristics

To develop a large enough sample of staff for statistical purposes, the researcher has decided to pool all the information about the staff at these three establishments together, making a total sample of 100 for the general staff and 75 for control room staff. In this way a more concise and consistent structure of staff, especially those working at the control rooms, would be identified. However, due to the sensitivity attached to the nature of their work, control rooms staff are examined separately.

Table 4.4 gives a summary of the characteristics of all the general staff as a whole and the control room staff in the three establishments. Of the total 120 questionnaires distributed to staff in all the three establishments, 100 completed questionnaires were received, giving a respectable response rate of 83%. Of the total collected responses 78% were found to be male, majority of whom (68%) found to hold Bachelor's degree, and 7% with postgraduate qualifications. Only 25% of these respondents declared to have had intermediate qualification. Furthermore, of the total staff working in these three establishments 44% held managerial positions, 34% clerical and remaining 22% were involved in administrative duties.

The researcher identified a small number of controllers in a number of branches of Alfardan jewellery (25 full time controllers) and between 50 and 80 staff in the two hospitals being directly or indirectly involved in activities related to control rooms. The researcher managed to have a 100% response from the Alfardan jewellery, but only 83% and 62% responses from HMC and SMC respectively. Whilst all the control room staff in Alfardan were found to be male, 24% and 32% female controllers were found to be involved in control rooms in SMC and HMC respectively.

A careful examination of Table 4.4 suggests that the number of control room staff holding university qualifications varied between 88% in Alfardan to 100% in the two hospitals. Only 12% of control room staff in Alfardan declared that hey held intermediate qualification. On the whole, it is evident that in terms of educational qualifications, the control room staff tend to be more qualified than the general staff working in other departments of these establishments. In particular, up to 28% of control room staff in HMC declared to have held postgraduate qualifications, compared to only 5% in SMC and 4% in Alfardan.

Finally, as for positions in their establishments and duties, the majority of staff were found to be involved in clerical or technical positions (between 44% and 58%), with much wider range of staff in managerial positions (12% to 36%). The remaining smaller proportion of control room staff declared to be involved in administrative activities.

When comparing the general staff with control room staff, it can be said that whilst 34% of the former group staff are found to involved in clerical or technical activities, this ratio reaches to 51% for the latter group of staff. Coupled with this is the fact that the control room staff are also more qualified and perhaps more able in conducting their duties. In summary, it is therefore anticipated that the control room staff are both capable and qualified workers and hence aware of their sensitive responsibilities and duties.

4.3.4 Control Room and Technological Characteristics

The quality of service provided by the qualified and experienced control room staff is extremely vital, but the use of advanced technology and frequency of monitoring are pivotal in maximising the effectiveness of CCTV surveillance systems. In the questionnaire designed for controllers a number of such factors were considered. Table 3 presents a summary of the characteristics of the control rooms in the three organisations. A number of points are worth noting here. Firstly, all three establishments have reported to use similar advanced technology (CAT 5 or 6) as their camera infrastructure. Understandably, for a private business with limited site size such as Alfardan one control point is justified. However, as for the hospitals with massive land and several departments and activities more control points are required. Here according to table 4.3, both hospitals reported to have 3 points for control in their entire sites.

Table 0.4 Characteristics of General Staff and Controllers

CHARACTERISTICS	Percentage of Staff			
	General	Control Room		
		Alfardan	HMC	SMC
Questionnaire Distributed	120	25	30	40
Questionnaire Collected	100	25	25	25
Response Rate (%)	83.0	100.0	83.0	62.0
Male (%)	78.0	100.0	68.0	76.0
Female (%)	22.0	0.0	32.0	24.0
Qualifications (%)				
None	0.0	0.0	0.0	0.0
Intermediate	25.0	12.0	0.0	0.0
Graduate	68.0	84.0	72.0	95.0
Postgraduate	7.0	4.0	28.0	5.0
Job Description				
Management	44.0	32.0	36.0	12.0
Clerical/Technical	34.0	52.0	44.0	58.0
Admin	22.0	16.0	20.0	30.0

As for number of cameras per site, Alfardan relative to its smaller size tend to have 8 cameras compared to hospitals with 12 cameras. As for monitors per point of control, both Alfardan and HMC possess 3 while SMC only reports one monitor per control point. Data retention is vital for potential reduction of crime in public places. Whilst Alfardan reports a 30-day retention of recording material, the two hospitals only keep the recording material for 7 days.

Finally, as a means of quality of CCTV surveillance, monitoring frequency represents the most important aspect of safety and reliability. Here, as a form of summary statistics the responses have been scaled as 1 being very infrequent to 3 being highly frequent. On this

basis, both SMC and Alfardan tend to offer poorer quality of monitoring compared to HMC which reports to have very frequent and regular monitoring system in place.

Table 0.5 Selected Number of Control Room Characteristics

Characteristic	Alfardan	HMC	SMC
Number of control points per site	1	3	3
Number of cameras per site	8	12	12
Number of monitors per point	3	3	1
Data recording retention (days)	30	7	7
Monitoring frequency (1 – 3)	1	3	1
Frames per second	50	100	50
Camera Infrastructure	CAT 5,CAT 6	CAT 6	CAT 5

From the findings shown in table table 4.5, it is fair to argue that HMC appears to perform better than the other two establishments in maintaining and monitoring their CCTV surveillance system.

4.3.5 Analysing Perceptions About CCTV: A Statistical Approach

When analysing the perception of people about CCTV surveillance systems in Saudi Arabia the researcher has pooled all the data collected from the two hospitals together and compared with those collected from Alfardan Jewellery. By applying some basic statistical techniques to the collected data, the study has transformed the qualitative classifications used for every question into a form of Likert scale. For those questions with 2 choices, a binary weight of 0 and 1 has been assigned. For the rest of questions weights of 1 to 4 have been used where 1 represents the highest level of disagreement or dissatisfaction with the question, and 4 being the highest level of agreement or satisfaction. Therefore, the weighed means calculated in this case could fall within 1 and 4.

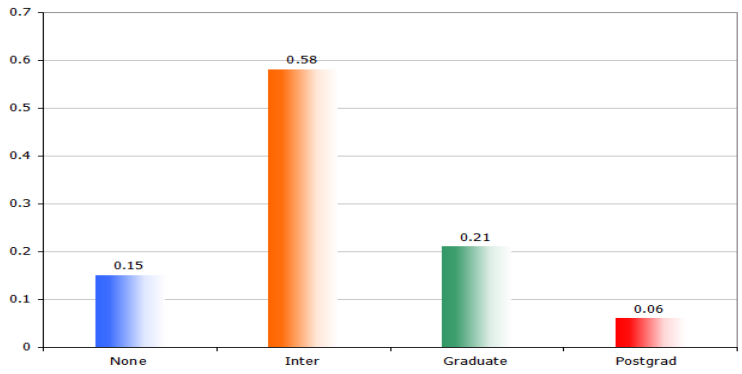
4.3.5.1 Customers/Patients Perceptions

A number of constructs or variables need to be examined carefully. Here, a number of relevant constructs have been highlighted shown in figures 4.1 to 4.6 for the entire sample

of participants (customers and patients). For other details relating to breakdown of data and associated charts, see Appendix A.

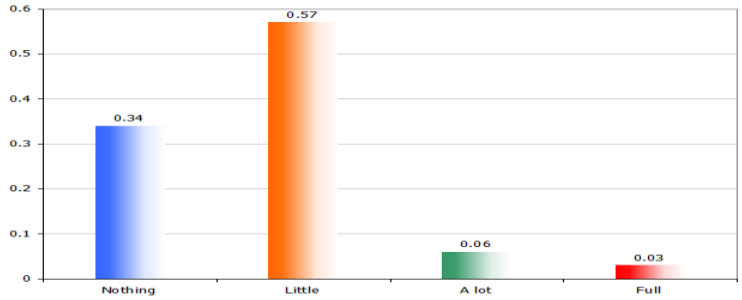
The educational attainment of customers/patients may appear to be not necessarily relevant here, but as can be shown later it could determine the extent of opposition or acceptance of CCTV surveillance system. From the results of figure 4.1, of the total 75 patients/customers, 15% declared they had no education qualifications whatsoever and just under 60% had intermediate or high school qualification. The remaining 27% declared that they had either Bachelors or postgraduate degrees.

Figure 0.1 Educational Qualifications of Participants



Knowing how the CCTV system work can help appreciate the usefulness of this form of surveillance. From figure 4.2 a staggering 34% of respondents said they had no idea about CCTV and 57% declared that they understood only a little bit about it. Surprisingly, only a handful of respondents said that they did know about CCTV and its working.

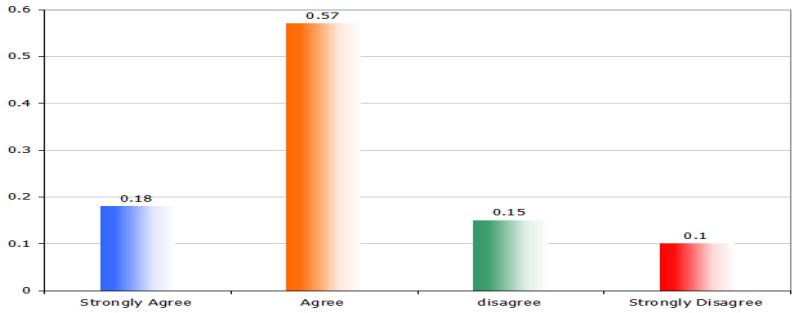
Figure 0.2 Knowledge about CCTV and its functions



Normally, once one has none or little idea about a particular technology and does not have the educational backgrounds to understand it then the fear begins to set in. This seems to be applicable to majority of respondents as they declared their concern about CCTV. On

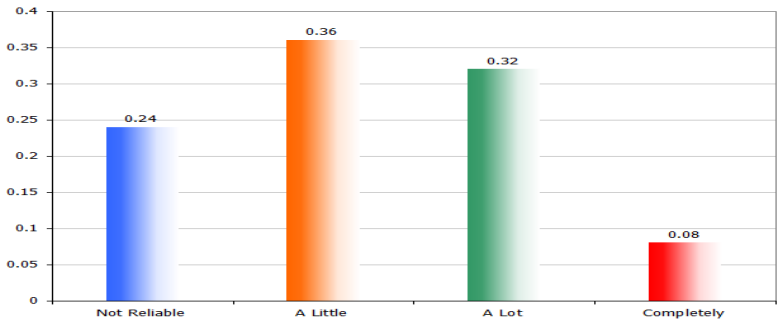
the whole, as figure 4.3 shows, 75% of respondents' perception about CCTV is negative and tend to oppose the further installation and applications of CCTV.

Figure 0.3 Concern about CCTV Surveillance Systems



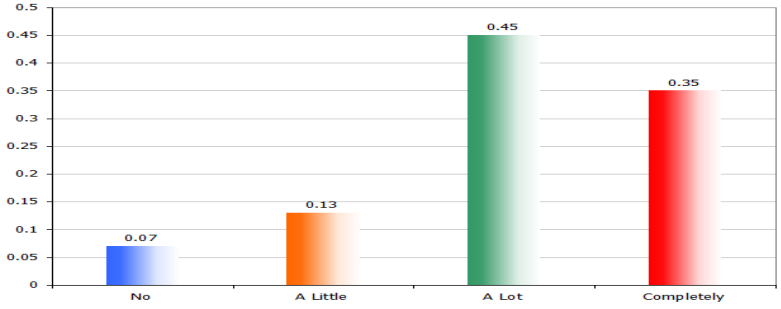
Despite the concern shown about CCTV surveillance, nearly 40% of respondents believe that it is a reliable system. However, as figure 4 shows, the remaining 60% believe that CCTV is either totally unreliable or only barely reliable.

Figure 0.4 Reliability and safety of CCTV in shops and public places



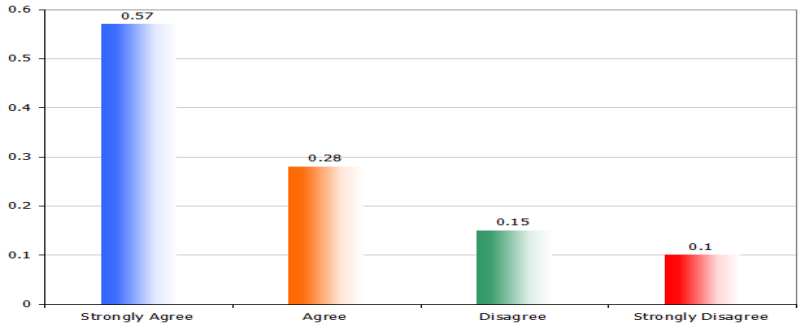
To determine sources of concern, the question asks if the respondents believe that CCTV does invade individuals' privacy and this is displayed in figure 5. Surprisingly, a large majority (80%) of respondents regard CCTV as a privacy invading surveillance system. Only 7% perceive CCTV as no threat to privacy.

Figure 0.5 CCTV as Invasion of Privacy



As another potential source of discomfort and concern about CCTV, 57% of the respondents declared that they strongly believed that CCTV could and would abuse their power. Another 28% also agreed that controllers could abuse the CCTV footage. Only 10% of respondents perceive strongly that the controllers would not abuse their power. Another 15% also are of the view that abuse by controllers would not happen.

Figure 0.6 CCTV controllers' abuse of the system



A comparative and detailed examination of the relevant factors discussed above are depicted in table 4.6 which presents the estimated mean values and standard errors associated to each construct. For a detailed breakdown of data and presentation of all other questions and associated bar charts, see Appendix A.

This table shows that in the case of the reliability of CCTV, the mean value turned out to be around 1.4 for the hospital patients and 1.38 for the Alfardan customers, but these mean values are significant. Moreover, the means differences suggest that there is no significant difference in the perception of the two groups as far as the reliability of CCTV goes. Despite the low values on the on the reliability, the safety issue of CCTV has received one of the highest scores – 3.12 from hospital patients and 2.70 from customers at Alfardan. Since these mean values are obtained with low standard variance errors, then they can be seen statistically significant. Moreover, the means difference is also shown to be statistically significant meaning that there are differences in the perception of people in relation to the safety of CCTV.

Moreover, the two groups of people have similar perception in the case of crime reduction ability of CCTV surveillance with the mean values being statistically significant, too. Against all that, there seems to be a significant concern about presence and prevalence of CCTV in public places. Where the hospital patients attach a relatively high mean value of 2.90 to being concerned about CCTV, the customers of Alfardan have exceeded it by

3.36. Although the means differences are being statistically significant between the two groups, the high value attach to concern is alarming.

Evidently, there are several factors which have given rise for the respondents to be concerned and in effect opposing a deployment of CCTV systems. A number of such factors have been picked up by the questionnaire. The three main factors have been found to be: (i) controllers' abuse of CCTV footage, (ii) misleading nature of CCTV evidence, and (iii) privacy invasion. Of these three factors, two have turned out to be very high: the controllers' abuse with scores of 3.14 and 2.75, and the privacy invasion with the mean scores of 3.04 and 2.88. These mean values are statistically significant. Only a small percentage of people believe that the evidence from CCTV could be misleading as shown by the mean value for this factor being just over 1.5.

Table 0.6Perception of Patients/Customers about CCTV

Construct/Question	Mean Value		St. Error		Means Differences
	Hospitals	Alfardan	Hospitals	Alfardan	
Reliability of CCTV	1.44	1.38	0.1221	0.2013	0.06
Safety	3.12	2.70	0.1665	0.1873	0.42*
Crime Reduction	3.23	3.20	0.0992	0.1431	0.03
Concerns about CCTV	2.90	3.36	0.0925	0.1242	-0.46*
Controllers abuse	3.14	2.75	0.0833	0.1562	0.39*
Misleading evidence	1.64	1.54	0.1012	0.2213	0.10
Privacy invasion	3.04	2.88	0.1154	0.1725	0.16

Notes: *Statistically significant at 5% level.

Table 4.4 shows very important findings in the case of the total sample of patients and customers: although people are aware of the safety and crime reduction of the CCTV surveillance, the majority of the respondents are still concerned about the presence and prevalence of CCTV. This may be related to issues such as its invasion of privacy, but more importantly to the perception that controllers may misuse and abuse the footage from surveillance.

Table 4.6 also provides a measure for a possible correlation which may exist among these factors. To do this, a simple measure of correlation, Pearson correlation, has been applied to the data, and the results are depicted in table 4.7. The second left-hand side column is the one to look carefully as it offers simple pairwise correlation between concern and the other factors. The largest number in this column relates to the correlation between concern and controllers' abuse which has turned out as 0.72, indicating a rather strong positive relationship, implying that the higher the perception about the abuse of CCTV footage, the higher would be the concern about and opposition to CCTV surveillance.

The correlation between the concern and privacy invasion has also turned out to be positive but much smaller. The correlation between reliability and concern is negative and around 0.46 indicating that the higher the perception about reliability, the lower would be the concern about CCTV. Similarly, the correlation between safety and concern has turned out negative indicating that, other things equal, the higher the perception of safety of CCTV, the lower would be the concern or opposition to such surveillance system.

Table 0.7Correlation Matrix using the entire sample size

	Concern	*Qualification*	*Abuse*	*Knowledge*	*Reliability*	*Priv_inv*	*Safety*
Concern	1						
Qualification	-0.65793836	1					
Abuse	0.723572866	-0.528187	1				
Knowledge	-0.15905785	0.54792074	-0.23608	1			
Reliability	-0.46853424	0.79079156	-0.33918	0.3530566	1		
Priv_inv	0.390583216	-0.76547139	0.404517	-0.500256	-0.69344	1	
Safety	-0.35252711	0.455026	-0.13251	0.0651388	0.09845	-0.18295	1

An interesting point shown in this table is that correlation between the qualification (an index of education achievement and a proxy for socio-economic indicator) and concern is relatively high and negative, implying that the higher the level of education the lower would be the concern or fear about CCTV surveillance. Moreover, as the third column shows, the higher the level of education is associated with the lower fear of privacy invasion and abuse of CCTV footage.

The correlation matrix, though a simple approach in looking into a complex world, has revealed that through education and provision of knowledge about CCTV it is possible to improve the negative perception of people about CCTV surveillance system as a whole.

Nevertheless, the issue of abuse by the controllers is a severe issue and people must be made assured that such abuse of power would not ever happen. Furthermore, an appropriate action should be taken against any CCTV controller found to have abused his/her power.

4.3.5.2 Staff Perception

When examining the staff perception of these three establishments, it has been decided to put all the data together in order to obtain a more comprehensive and consistent estimates for the variables in question. The following five questions, put forward to the staff at the three organisations, have been picked up to serve the aim of the research:

Q 1: Views about CCTV as crime prevention;

Q 2: Feeling safe on job in the presence of CCTV;

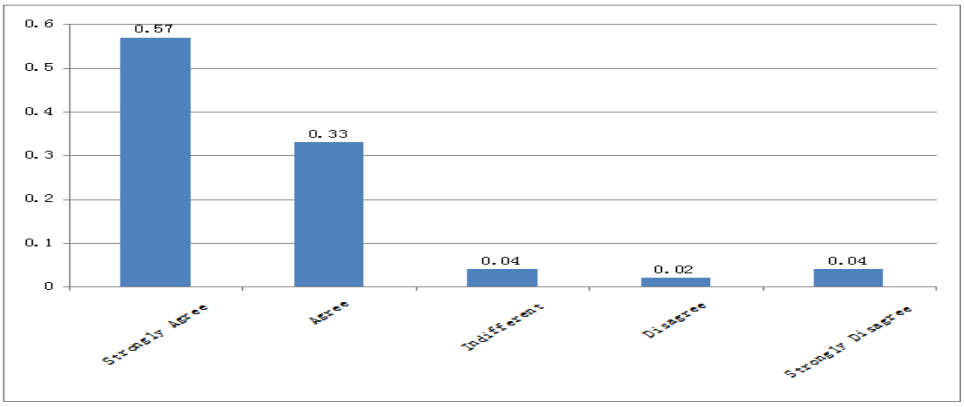
Q 3: CCTV as an instrument in improving working environment;

Q 4: CCTV helping improve productivity; and

Q 5: CCTV helping monitor and resolve effectively incidents at work.

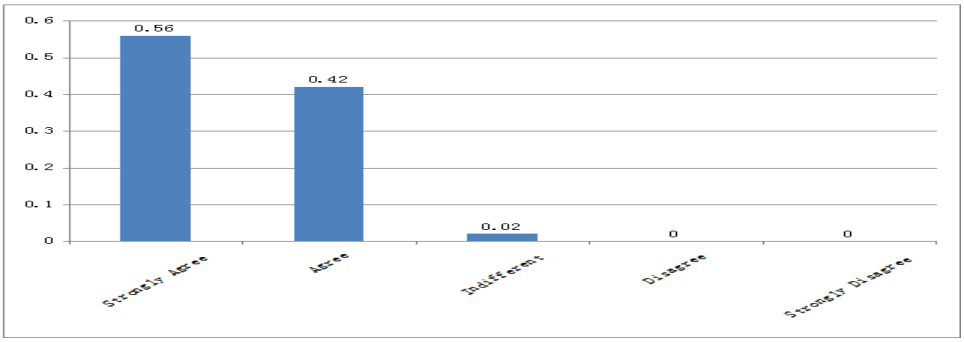
In relation to the above pivotal questions, figures 4.7 to 4.11 present the distribution of responses for all the staff in the three establishments. On the issue of crime reduction ability of CCTV surveillance system, as shown in figure 4.7, up to 90% of staff strongly believe that it would do so. Only 6% of staff disagree or strongly disagree with effectiveness of \CCTV in crime reduction.

Figure 0.7 CCTV as a Crime prevention system



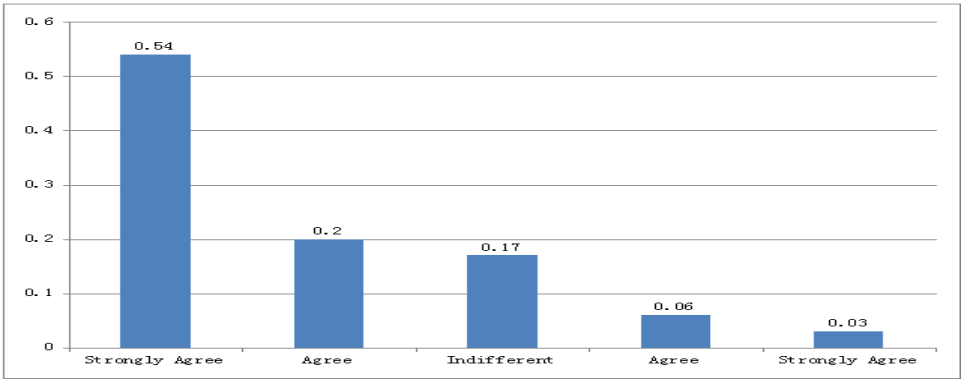
When the staff asked about their view on safety element of CCTV at workplace a staggering 98% agreed or strongly agreed with the statement. The distribution of responses to safety issue of CCTV is depicted in figure 4.8.

Figure 0.8 Feeling safe on job in presence of CCTV



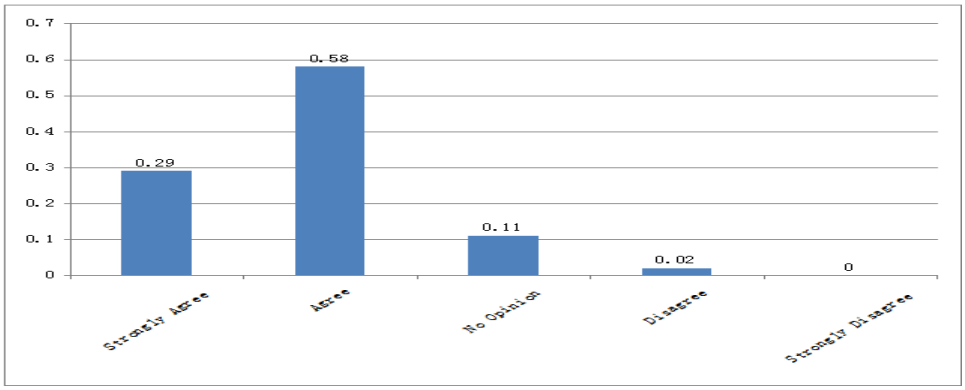
When asked about the potentials of CCTV system in helping improve the overall working environment, up to 74% of all staff agreed or strongly agreed that it would do so. However, as depicted in figure 4.9, only 9% of staff disagreed or strongly disagreed with this statement.

Figure 0.9 CCTV helping improve working environment



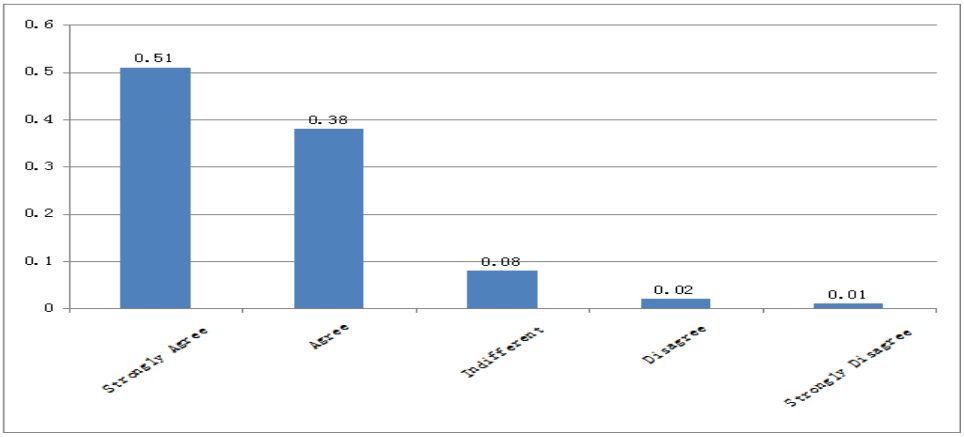
On the issue of whether CCTV would be able to helps improve the productivity, although only 29% strongly agreed with this, a staggering 58% also agreed that it would do so. Once again and as shown in figure 4.10, only 2% of staff disagreed with the statement.

Figure 0.10 CCTV helping improve productivity



Finally, when asked about the potential of CCTV helping monitor and resolve incidents at work effectively, as shown in figure 4.11, once again 89% of staff agreed or strongly agreed with this statement. With 11% having no opinion or being indifferent, only 2% of staff disagreed with the possible ability of CCTV system in effectively resolving incidents at work.

Figure 0.11 Helping monitor and resolve incidents at work



Based on the above questions, table 4.6 presents the perception of the staff in all the three establishments based on mean value and estimated standard errors. The table presents very high scores of between 3.95 and 4.42 for different questions posed to staff in all the three organisations. These results obtained are generated with relatively small standard errors, indicating that they are all statistically significant at the 5% level of significance.

Table 0.8 Perception of all staff about CCTV

Construct/Question	Mean Value	St. Error
Q1: CCTV crime prevention	4.37	0.8392
Q2: Safety at work	4.33	1.0293
Q3: Improved working environment	3.95	0.8753
Q4: Improving productivity	4.42	0.9044
Q5: Effective dealing with incidents	4.38	1.0443

Not only do the staff believe CCTV can work as an effective means of crime prevention, they also attach large values to the effectiveness of CCTV in improving the working conditions, thus enhancing the safety at work and improving the overall productivity of workers. Furthermore, and more importantly, they exhibit a high positive perception about the effectiveness and efficiency of CCTV in dealing with incidents at work. Therefore, by giving high weights to positive features of CCTV, the staff tend to allocate much lower weights to negative features such as privacy invasion

and general concern about use and implementation of CCTV surveillance system.

4.3.6 Multiple Relationship among Constructs: A Regression Approach

The previous section shed light into a potential multiple relationship which may exist between concern, privacy invasion and controllers abuse. Since the concern or opposition to CCTV can be influenced by a number of factors, a simple general form of mathematical relationship can be shown as:

$$Yi = f(Xi, Zi) \quad , \quad [I = 1, 2, 3, \ldots, n] \qquad (4.1)$$

where Y represents concern about CCTV, X and Z represent privacy invasion and abuse, respectively. In a more statistically presented format, expression (4.1) can be shows as (Stapleton, 2009: 83-87):

$$Yi = \alpha + \beta Xi + \gamma Zi + e_i \qquad (4.2)$$

In equation (4.2) the parameters α represents the constant term of the model, and β and γ are the estimated coefficients attached to X and Z. The disturbance term of the model is given as e, with zero mean and constant variance. In cases where a dependent variable is continuous data, regardless of the nature of independent variables, a linear regression model of the form shown as expression (4.2) is advisable, provided there are no inter-relationships between X, Z and the disturbance term. Furthermore, it is strongly assumed that there is no correlation between the explanatory variables and the error term.

Given the nature of the data (non-continuous, multinomial), particularly that relating to the dependent variable (Y), then any attempt to estimating a linear model may fail to work. Thus, in the light of this form of dependent variable, the appropriate estimation method is a hill-climbing multinomial logistic regression. Logit or logistic models is a special case of linear regression where the former assumes S-shape cumulative distribution compared to the normal distribution. The S-shaped distribution is used to give the maximum limit that the dependent variable can reach (Foster, 1997). For example, in the case of binary dependent variable, the S-shaped distribution limits the dependent variable to change from zero to unity. Hence the logit model uses probabilistic approach to measure the chances that the dependent variable becomes zero or one, based on the changes in explanatory variables (Harrel, 2001).

The advantage of this form of distribution is that its cumulative function has a closed form expression in terms of ratio of exponentials, as follows:

$$F(y_j) = X\beta_j + u_j \qquad (4.3)$$

In equation (4.3), the matrix x represents a matrix of all explanatory variables over the entire sample. In this expression, j in the binary form can take two values of zero and one, and in this study it takes values 1,2,3 and 4. This case is sometimes referred to as categorical ordering logistic model (Agresti, 2002).

To build the model, it can be argued that, as stated by the participants, abuse by controllers and privacy invasion should be considered as factors causing concern about or opposition to CCTV systems. In a simple means deviated form, the logistic model can be shown as:

$$\text{Ln}(Pi/1\text{-}Pi) = x\beta + \varepsilon i \qquad \varepsilon i \sim \text{NID}(0, k) \qquad (4.4)$$

The term Ln(Pi/1-Pi) or the odds-ratio, represents here the log-natural of the ratio of probabilities of Y taking different values between 1 and 5. In expression (4.4), β represents a positive vector of the parameters attached to explanatory variables, here

being privacy invasion (X1), and abuse by controllers (X2), embodying the partial elasticities within the logistic regression. This is to say that if X goes up by one percent, then dependent variable is expected to go up by β percent. The error term, ε, is normally and independently distributed with zero mean value and fixed (k) variance (Barreto and Howland, 2010).

It must be noted that since the estimation process of equation (4.4) is based on the application of a non-linear model, known as maximum likelihood estimation, then the potential problems discussed earlier would not arise. This is to say that the estimation procedure here, unlike that of linear regression model, yields an unbiased vector of β, hence making prediction more efficient and consistent (Maddala, 1992).

On the other hand, as identified from the questionnaire and examination of the correlation matrix, general higher education and knowledge about CCTV tend to lower concern or fear about CCTV. This means that providing general higher education and more specific knowledge about CCTV can help people appreciate the benefits of CCTV and hence reduce concern about the surveillance systems. In the light of this phenomenon, one needs to incorporate a product of knowledge and education into expression (2) to derive the final version of the multinomial logistic model. In short, the final form of expression (2) has three explanatory variables, as follows:

X1: Privacy invasion

X2: Abuse by controllers

X3: Education qualifications multiplied by Knowledge about CCTV

For the purpose of comparison, prior to estimating the logistic model, a linear regression version of the model has been estimated and the results of which are presented in table 4.7. The overall model has yielded an R^2 of 0.659, indicating that the three explanatory variables explain over 65% of variation in the dependent variable and that the remaining variation in dependent variable is still unexplained. According to table 7, the estimated coefficient of privacy invasion (X_1) has turned out meaningless and statistically insignificant. However, the estimated coefficients attached to controllers' abuse (X_2) and X have turned out statistically significant and meaningful.

According to these estimated results, the higher the level of education/knowledge the lower would be the concern/fear/opposition toward CCTV. The coefficient attached to abuse has turned out positive and significant, indicating the importance of fear of

controllers' abuse in creating concern about CCTV. Since the privacy invasion variable has turned out insignificant, the second panel of the table offers the linear regression estimates without the variable. As can be seen the exclusion of X has improved the model as the F-Statistic has gone up from 13.58 (in model 1) to 18.65 (in model 2). In the second model, again the significance of education/knowledge coefficient implies the importance of education and knowledge of CCTV in reducing concern about CCTV technologies.

Using the SPSS-IBM software for the estimation of multinomial logistic function, expression (2), table 4.8 shows the final estimated results for the parameters, M-Fadden R-Squared, LR Statistic and the probabilities of concern attached by each group. Groups are made based on the level of education and knowledge combined as follows:

Group 1: No qualification or knowledge of CCTV

Group 2: Lower level of education and knowledge of CCTV

Group 3: Higher education qualification and knowledge of CCTV

Table 0.9 Estimated Linear Models, based on all participants

Model 1				**Model 2**			
Coefficient	Value	St. Err	Significance	Coefficient	Value	St. Err	Significance
Constant	3.015	1.204	(0.01)	Constant	1.976	0.836	(0.00)
X1	-0.227	0.164	(0.11)	X2	0.572	0.161	(0.00)
X2	0.572	0.162	(0.00)	X3	-0.406	0.167	(0.00)
X3	-0.628	0.226	(0.00)				

R^2 = 0.659 F-Stat = 13.58 R2 = 0.629 F-Stat = 18.65

Since the variable X3 is a product of the two factors (education qualification and knowledge of CCTV), then any person found to have higher education qualification but no knowledge of CCTV, he/she would fall into group 1. Any individual with intermediate qualification and knowledge of CCTV (higher or lower knowledge) would fall into group 2. Finally, if the individual was found to hold higher degrees and knowledge about CCTV, would fall into group 3. Since education and knowledge vary between 0 and 3 (zero for no knowledge or no qualification and 3 for high level of knowledge or postgraduate degree), therefore, X3 can take values between zero and 9.

The estimated coefficients for the three variables are shown to be statistically significantly different from zero. The estimated coefficient of X1 (privacy invasion) has turned out to be positive, indicating that a one percent increase in privacy invasion perception, other things equal, would lead to 0.5342% increase in concern or opposition to CCTV. Moreover, the estimated elasticity relating concern to controllers' abuse (X2), as expected, has turned out to be positive and higher than that of X1, indicating that a one percent increase in believing in controllers' abuse of CCTV would lead to 0.8631% increase in concern about CCTV.

The interesting point of table 4.9 is that the elasticity of X3 (product of education and knowledge) has turned out to be negative (as anticipated) and statistically significant, implying that a one percent increase in a combination of knowledge of CCTV and general higher education would lead to 0.4266% drop in concern about or opposition to CCTV surveillance systems. The average log-likelihood ratio (LR) of 0.2411 is translated into overall probability (odds-ratio) of 0.56, implying that the average participant with average values attached to their perception about different aspects of CCTV have 56% chance of being concerned about or opposing the CCTV surveillance systems.

The examination of probabilities of being concerned about CCTV shows substantial variation when participants are grouped into the three categories discussed above. As the table shows, for an individual with no knowledge of CCTV and/or no educational qualification the probability of being concerned about or opposing CCTV grows to 0.69 compared to the average probability of 56% - 13 point percent or nearly 23% higher. On the other hand, an individual falling within the group 3, being knowledgeable about CCTV or having higher education attainment, has much lower chance of being concerned about CCTV and hence less against the implementation and installation of CCTV surveillance systems.

The findings derived from the application of logistic model provide the researcher with a number of policy tools in the aid to identify and measure the extent of severity of opposition to CCTV surveillance systems and root causes for such opposition and concern. First and foremost, the findings suggest that a large proportion of respondents do appreciate the benefits of CCTV, such as safety and reliability and its potential for crime reduction. Nevertheless, the concern about CCTV seems to outweigh the benefits. The findings show that concern, as a dependent variable, is very sensitive to both privacy invasion and controllers' abuse of CCTV footage. The overall elasticities associated with these two variables add up to 1.4, meaning that other things equal, a one percent increase in each of the two explanatory variables would lead to 1.4% increase in concern about CCTV.

On the other hand, the inclusion of a product of education and knowledge as another explanatory variable has been proved useful as it shows that it can help reduce tensions or concern about CCTV. It is demonstrated that individuals with sufficient knowledge of CCTV and/or high level of education tend to have less concern about or oppose to CCTV surveillance. Hence, such individuals tend to attach much greater weights to benefits of CCTV rather than concerns about different possible negative factors surrounding CCTV Technology.

Table 0.10Estimated Logistic Function (Expression 2), based on all participants

Coefficient	**Value**	**St. Error**	**Significance**
Constant	0.8769	0.0993	0.000
X1	0.5342	0.1046	0.001
X2	0.8631	0.1004	0.000
X3	-0.4266	0.0921	0.000

McFadden R^2 = 0.2577

Average LR = 0.2411

Overall Probability = 0.56

Groups Probabilities:

Group 1: 0.69

Group 2: 0.57

Group 3: 0.43

A comparative study of the findings derived from table 4.8 with those from use of linear regression models (table 4.7) shows that the former offers much greater insight into the critical analysis of the constructs. Furthermore, whilst the latter yields insignificant value for coefficient of privacy invasion (X_1), the former model turns out to give an overall consistent and unbiased estimator for all the important variables in the model. This is because the logistic model uses a non-linear maximum likelihood approach satisfying the S-shaped distribution attached to dummy dependent variable.

4.4 Analysis of Interviews

As explained earlier, the interviews were performed primarily in support of the findings from the questionnaires. Furthermore, interviews would provide a platform for the interviewees to extend and elaborate on any issues that they felt strongly about. Since the concern about the role of control room staff was strongly echoed through the questionnaires, it was intended to concentrate more heavily on this group of stakeholders than the others. In so doing, the researcher conducted the interviews of six patients/customers, six general staff working in hospitals and he jewellery shop, but conducted 10 interviews of controllers in these three places. In so doing, the following three questions were set and posed to customers/patients of the two hospitals and the jewellery shop:

(i) During your visit/stay did you notice any CCTV cameras in the place?

(ii) What is your view about the presence of CCTV cameras in public places?

(iii) Does the presence of CCTV cameras make you feel more secure? If not, what would you suggest to improve safety and security?

Similarly, the following questions were set and posed to the selected staff at these three places:

(i) Would you identify any issues with the current CCTV implementation in your workplace?

(ii) Do you think the presence of CCTV help improve the work environment and performance in your workplace?

(iii) Would you think that some areas in the workplace should be kept CCTV-free zones?

Finally, the following four questions were presented to the staff working in control rooms of these organisations:

(i) How long have you been working with CCTV systems?

(ii) Which camera do you prefer to use and why?

(iii) What is your opinion about frame-rate and file-size?

(iv) What are your thoughts about implementing a semi-automated system for detection of artefacts before being displayed?

4.4.1 Customers/Patients' Views

Three patients at the two hospitals and two customers in the jewellery shop agreed to be interviewed. In the case of question 1, all the participants stated that the CCTV cameras were clearly visual and hence they noticed their presence. However, for question 2, there were some disagreement among the respondents. Whilst the hospital patients were of the view that such cameras should be placed in all public places, the customers at the jewellery regarded such cameras as intrusion. In particular, one of the customers of the jewellery shop stated that while the small shopkeepers must be vigilant, they should follow the strict Islamic laws regarding video recording of Muslims.

Finally, when the respondents were asked about the issues of safety and security of CCTV systems, a general agreement of the usefulness of such cameras was reached. A patient stated that whilst he condoned the use of CCTV for security purposes across the country, he warned that a number of such deployments have been wrongly implemented by the government. On the other hand, he added that the introduction of CCTV cameras at schools and colleges have been the best strategy that the government has made despite all the opposition from the religious quarters. A customer at the jewellery supported the deployment of CCTV systems in public places but insisted that they should be carefully monitored and supervised by independent agencies for effectiveness.

4.4.2 Staff Views

Six staff on the whole, 2 from each organisation, were interviewed. As for question 1, the majority of staff declared that they had very little knowledge or familiarity with CCTV systems, but were of the view that CCTV cameras could help enhance the safety and security at work. One member of staff at a hospital stated that he was experienced in dealing with use of CCTV systems but was anxious that most such staff are currently under-qualified and untrained to meet the standards required.

In relation to question 2, a number of constructive suggestions were made by the staff. In one of the hospitals, a member of staff stated that the presence of CTV cameras in sensitive places has significantly enhanced the productivity and performance at the workplace. He added that in some cases the patients have complained that there have been too many cameras in some private areas. Another member of staff was worried that a number of CCTV cameras were not fully operational for a long period of time and that the management had failed to address these issues. Finally, a member of staff at the jewellery said that the presence of CCTV cameras had improved the staff relations significantly. Furthermore, he pointed to the fact that since the installation of CCTV the cases of theft have been reduced in and around the shop significantly.

Finally, for question 3, all the staff interviewed stated that a number of places in the workplace should be kept camera free. In particular, most staff declared that places such as restaurants, rest rooms and mosques must be kept CCTV free at all times.

4.3.3 Controllers' Views

Of the 10 staff at control rooms who were interviewed in these three places, 2 were in the jewellery shop and 4 each in the other two hospitals. In answering the first question, the hospitals controllers demonstrated that they have been involved in working with CCTV systems somewhere between 3 and 5 years. The two controllers in the jewellery shop had only worked for up to three years in CCTV systems. These two controllers were of the view that the quality of training that they had received from the company was limited and inconclusive. They urged that more frequent training was required so that they could be at par with the controllers in public offices. The issue of periodic training programme was also echoed by two members of control room staff in one of the hospitals.

In relation to question 2, all the controllers were of the view that analogue wired IP cameras were preferable for their image quality and storage capabilities. In addition, they were all of the view that the fixed cameras tend to be least costly and easier to maintain. However, two controllers from the hospitals stated that movable cameras must be also considered for most sensitive areas in the hospital. On the question of frame rate and file size, no agreement was received from these controllers. On the whole, both frame rate and file size were regarded as equally important from these controllers' point of view.

Finally, in the case of implementation issue of a semi-automated system, no strong views were expressed. One controller in a hospital was of the view that the current technology may not be able to cope with a semi-automated system, but stressed that the introduction of such a system can significantly reduce stress and pressure on the staff. The staff in the jewellery's control room were not aware about semi-automation system for small businesses as they believed it could be costly and not necessarily effective.

On the whole, the main issue raised rather strongly by all the controllers was that of lack of training at workplace. The issue of periodic training and useful courses in control room management was particularly echoed by staff in the two hospitals.

4.5 Summary

This chapter has dealt with the analysis of the questionnaires and interviews; with the former designed and distributed to three groups of respondents: patients/customers, staff of two hospitals and a jewellery shop, and CCTV controllers in these three establishments. Although the detailed distribution of data and associated charts have been left to the chapter's appendix, a number of relevant issues considered and evaluated, using statistical inferences and application of an appropriate regression models. The overall findings in this chapter can be summarised as follows

(i) The early examination of the characteristics of both staff and clients (customers/patients) showed that whilst a significant number of respondents have positive perception about the benefits of CCTV, they tend to have concern about a number of issues surrounding possible abuse by the controllers and privacy invasion of CCTV.

(ii) The application of logit showed that both explanatory variables were statistically significant in explaining concern about CCTV. In particular, it was shown that the total effect coming through the two explanatory variables to concern about CCTV exceeded unity. However, the inclusion of a variable representing

education attainment and knowledge of CCTV can help reduce concern or opposition to CCTV surveillance.

(iii) The estimation of logistic model has helped derive a number of probabilities attached to individuals becoming concerned about CCTV. Although the overall average probability of becoming concerned turned out to be just above 50% mark, it varied significantly from individual to individual. It was demonstrated that an individual with either no educational qualification or no knowledge of CCTV can have a probability of around 70% of becoming opposed to CCTV deployment. On the other hand, an individual with high level of educational attainment and high knowledge of CCTV has only 43% chance of opposing to CCTV, some 27 % lower than the former group.

(iv) In support of the findings from the questionnaires, a number of interviews of the three stakeholders were conducted and the findings were in agreement with the earlier statistical results. In particular, the staff in the control rooms were strongly in favour of the introduction of more structured and frequent training programmes in technical courses and management awareness.

Generally, the findings from this chapter have provided the researcher with a number of policy implications. In particular, it is clearly shown that the provision of accurate and straightforward knowledge about CCTV technology and its potential benefits can help reduce concern about CCTV significantly. Such a strategy should be promoted and financed by the Saudi government to encourage the deployment of CCTV technology nationwide. Furthermore, both private and public institutions must make every effort to recruit qualified and trustworthy CCTV controllers, and publicise this action loudly and clearly to the public at large. In this way, it is hoped that the current perception about abuse of CCTV by controllers will be significantly lowered.

CHAPTER 5: PROPOSED FRAMEWORK

5.1 Introduction

To highlight the objectives of the current research, this chapter is structured to consider a number of relevant aspects of the study. A summary of the framework is presented in diagram5.1 highlighting, from both theoretical and practical viewpoints, six main areas for consideration. These issues represent the overall boundary and scope of the current research, serving as a guideline in achieving the answers to the questions of the thesis. Within the broader category of theoretical foundations, these six subjects include the following:

i) Deployment and applications – this is to be presented in reference to the theoretical issues surrounding the case of Saudi Arabia's deployment and implementation of CCTV surveillance systems, and in consideration of sensitive issues such as cultural and religious factors.

ii) Risk management and security requirements – this is conducted by making reference to several risk management issues relevant to CCTV surveillance from both the private and public sector viewpoints.

iii) Legal issues – the justification of deployment of CCTV systems in relation to the legal and privacy issues appear to be highly sensitive matters. In particular, in relation to the cultural and religious backgrounds of Saudi Arabia, this has proven to be a challenging one. This part also includes both legal international and national documentation in support of the implementation and deployment of CCTV systems.

iv) Technical applications – the challenges that can also face the deployment and implementation of effective CCTV surveillance systems may well be associated to technological constraints. This part attempts to identify the areas where technical constraints can adversely impact on effective CCTV deployment; and hence propose the ways in which advancement of technology could remove a significant number of such constraints.

v) Certification and training requirements – this part attempts to highlight the importance of effective and workable training programmes and relevant

education required to produce a mass of responsible and trained staff in support of CCTV management. In particular, appropriate certification through both training and education can enhance staff productivity and awareness of the sensitive issues relating to monitoring and control of CCTV footage and evidence.

vi) Government protocol and CCTV – in producing effective and efficient systems of surveillance in the country, the Saudi government is deemed to create a sensible and workable set of protocols for deployment, implementation and management of CCTV surveillance system. Relevant aspects in relation to Saudi government's protocol for CCTV system are discussed in this part.

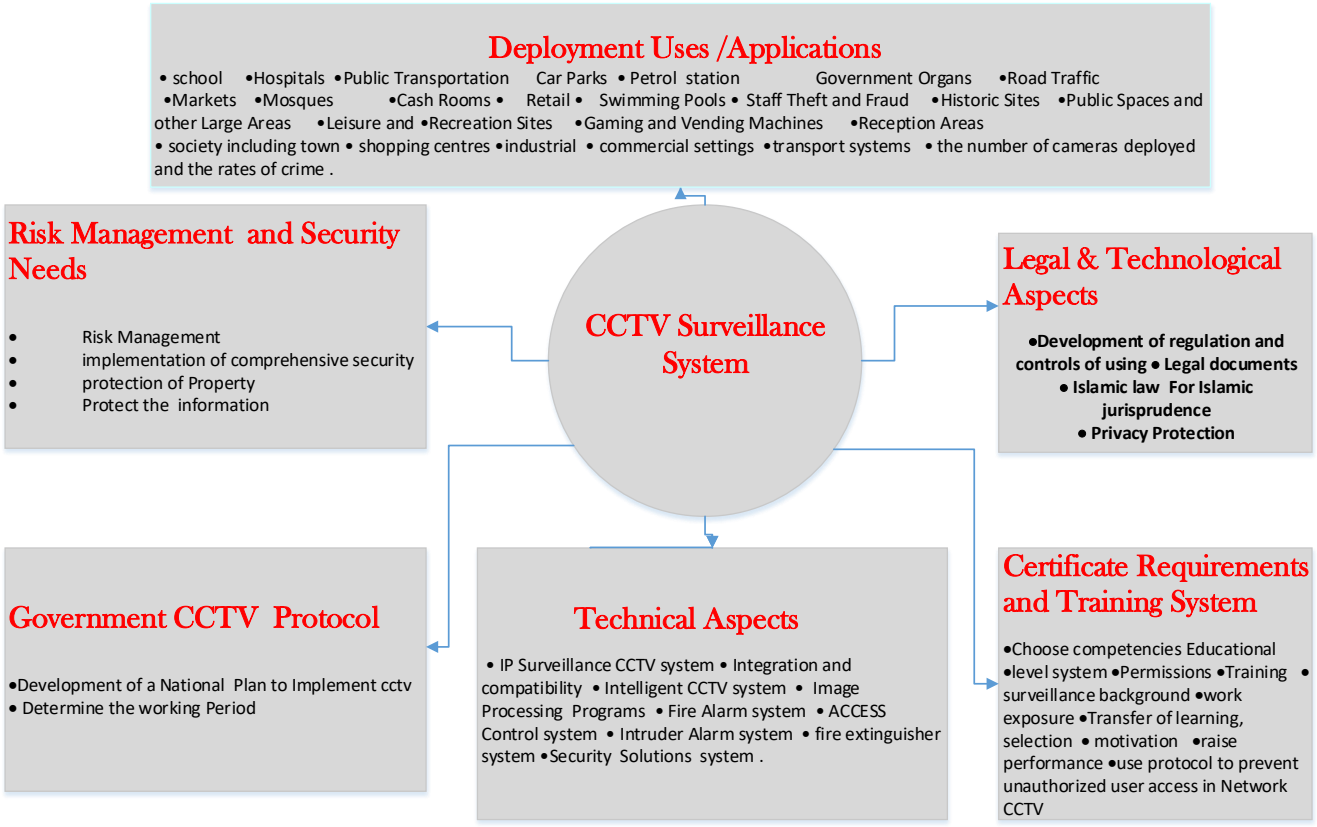
The main aims related to a set of recommendations proposed relating to practical aspects and implications of CCTV surveillance systems in Saudi Arabia, incorporating issues arising from cultural, environmental and governance aspects.

The chapter is organised as follows: Section 5.2 discusses the theoretical foundations used including their implications when a deployment in Saudi Arabia is done. Section 5.2 .

5.2 Theoretical Foundations and Implications

As it was discussed in the literature review chapter, there are several considerations to be considered when deciding to deploy CCTV surveillance system in a given country. Although a general theoretical framework tends to be applicable to all cases, in practical terms a number of socially and culturally bounded factors must be examined carefully prior to any action vis-a-vis deployment and implementation of CCTV systems.

Figure Structure of Framework 5.1



5.2.1 Deployment and Applications

As has been elaborated in the previous chapters, the use of CCTV surveillance systems to monitor public and private places does make sense as it is regarded as the most effective tool of crime reduction. Theoretically, the deployment of CCTV, particularly in sensitive public places, is justified provided several social, cultural and technical aspects have been fully considered. For its ease of use and maintenance, as elaborated in Ferguson (2010), a CCTV system can be designed to be installed internally or externally, visible or covert, static or movable. However, the most difficult and cumbersome and hence sensitive issues relate not to physical aspects of CCTV system itself but its impact on social, cultural, legal and other relevant considerations. Furthermore, because of this very nature of CCTV deployment, the procedures for implementation and deployment of CCTV tends to vary significantly from country to country and region to region.

In the case of Saudi Arabia, with its massive developmental leap and recent successful economic performances, the deployment of CCTV technology in a number of public places has proven to be challenging and controversial. The strict Islamic laws can prevent the country's full deployment, as according to such laws no power could take

picture/video or acquired picture/video of the citizens without their consent. Therefore, it is very hard to make the case for CCTV System. With the government recent initiative, as stated in previous chapters, by installing CCTV cameras in 33,000 schools around the Kingdom, it will provide better initiative steps for CCTV future deployment in Saudi Arabia. The Saudi government has promoted the idea that CCTV systems would help ensure the physical and operational security around Saudi Arabia business, commercial and housing areas.

One of the earliest forms of CCTV surveillance systems in Saudi Arabia, as mentioned in the previous chapters, was deployed in a number of motorways and dual carriageways with the aim of speed control and general safeguarding of drivers, enabling easy flow of traffic. This system is primarily based on the previous research on automatic number plate recognition of cars which is based on template matching concept. This system has been improved on a yearly basis across the country, and currently it enjoys state-of-the-art technology enabling the control and detection of speed, traffic composition, vehicle shapes and types, number plate identification and all occurrences of traffic violation or road accidents. Up to now, the government's reports are concerned, no serious opposition has been lodged against the effectiveness and efficiency of this system.

In order to promote the deployment of the so-called distributed multimedia surveillance systems in both public and private places in Saudi Arabia, recent research has demonstrated that such systems would utilise heterogeneous sensors like cameras, motion sensors, sound sensors and RFID in providing safety and security for all. However, such research has also highlighted the sensitive issues surrounding clients in public places and patients in hospitals and students and pupils in education. As demonstrated in chapters four and five, based on the study's case, a significant number of patients in the two hospitals examined were opposed to the idea of CCTV cameras in certain areas of hospitals. As it was shown earlier, the privacy-sensitive data obtained from distributed visual sensors were the centre of controversy. In particular, as the results of the questionnaire showed such opposition to deployment of CCTV in hospitals stemmed from the fact that the general public does not trust CCTV controllers.

Despite such general opposition to deployment of CCTV system in public places, one of the most controversial and heated CCTV surveillance installation projects in Saudi Arabia was related to monitoring the density of pilgrims during the annual Hajj in Makkah. In the end, the government won the case against the opposition by installing a sophisticated surveillance system, built by France's Thales, and designed to prevent accidents and

stampedes when pilgrims cross over the Jamaraat Bridge, where fatal stampedes had previously and almost every year occurred and led to several fatalities and serious injuries.

Although there seems to be a long winding road ahead of the Saudi government in educating the masses about the usefulness of CCTV system, the recent moves in extending and enhancing surveillance system across the country's sensitive places has demonstrated some victory for the government. This kind of initiative along with recent directions warning the nation about the severe threat of terrorism has made the public more in favour of CCTV deployment in both public and private places. In short, whenever the security issues are brought about, the public would become more aware and supportive of deployment of CCTV surveillance system in public places.

According to a major research consulting think-tank, Saudi's CCTV market is expected to grow at an annual rate of 5% during 2015-19 (TechSci, 2014). In particular, concurrently, due to security issues surrounding threat of terrorism in the country along with the ongoing major infrastructural investment there will be more prevalence of new technology adoption in deployment of more CCTV surveillance system. Having held a number of meetings with top players in CCTV markets, the government has invited companies such as Bosch and Axis Communications to expand their IP production base along with technologies such as VSaaS and mobile video system in Saudi Arabia by the end of 2019.

5.2.2 Risk Management and Security Requirements

Any activity or event brings with it a number of uncertain and risky outcomes. Where uncertainty cannot be measured but only hypothesised, risk can be measured using a probabilistic rule. In simple terms, a risk is therefore a combination of the probability of a negative event and its consequences. It should be borne in mind that if an event is inevitable but trivial, it presents no risk, simply because it has no impact. In short, a risk attached to a given activity or project, consisting of several events, is the total sum of events multiplied by their respective probabilities and consequences (Hopkin, 2014).

One easy way to reduce or control risk associated with a given project is to eliminate ambitious or unknown goals. However, after risks associated to each and every event have been evaluated, then one can choose a path of risk avoidance or determine ways of managing such risks. It is therefore a common sense to identify and measure the potential risks of a project, so that decision should be made to either reduce of mitigate such risks

to an acceptable level. Furthermore, it is clear that risks attached to events which offer no potential gain must be avoided or eliminated. For example, the installation of CCTV cameras in unpopulated non-strategic areas produces no potential benefit and yet can be costly to deploy and maintain. On the other hand, risks related to such events which offer challenging and worthwhile goals should be managed. Therefore, a risk can be reduced or managed if one finds the way to either reduce the probabilities of failure or to minimise the negative consequences arising from risky events.

Issues relating to security and public protection projects do normally embody a number of risky and uncertain events. The risky elements are usually derived from previous experiences and known events. However, the uncertain elements are either new to project manager or difficult to identify or measure. Indeed, any event within a given security project plan that appears to be important tends to be unmeasurable and has to be considered as risk areas and given special attention. In effect, risk to security should be associated with areas where the scope is unclear or is constantly changeable. For example, use of a new technology or a technical method may in certain times prove to be complex and difficult to measure, hence increasing the overall project risk. Similarly, having inexperienced or untrained staff can seriously increase risk attached to the project. In short, any area which the project manager fails to have control over can potentially present high risk.

The relationship between the people involved in both perception and use of CCTV surveillance system can be challenging as the complexity of designing, devising and implementing the risks associated with social and spatial relations vis-à-vis CCTV systems. Research in this area has found a number of significant risks. The highest risk can be associated to pre design and implementation stages, primarily relating to CCTV location, its potential effectiveness and costs. Furthermore, there are potential risks associated with the relationship between the decision-makers and the end users, mainly to do with regulatory measures suiting the public perception and culture. It can therefore be stated that risk management attached to design, deployment, effectiveness and maintenance of CCTV surveillance system can be a very delicate task as it deals with the public at large.

Risk management associated with technological advancement and applications, particularly in dealing with unexpected terrorist activities requires a proactive management strategy which employs the technology that he is well aware that it would reduce risk and enhance effectiveness. Although the development of a concrete and fair

auditing and regulation in managing risk has been promoted by experts, one has been warned that any intensified surveillance and over-regulated system can severely increase system complexity and confusion, hence increasing risks and uncertainty. Therefore, risk-management systems can potentially restrict freedom, invade privacy, discriminate, and exclude people, if they fail to incorporate value questions about human rights, well-being, prosperity, and solidarity.

Once the risks associated with a particular project are identified, the next question is how to measure such risks in order to evaluate the extent of damage that they could potentially inflict. One of the commonly used approach is referred to as PERT (Program Evaluation and Review Technique) which uses the previously gathered information about a number of events of a similar project to calculate the expected (or mean value) outcomes (Pritchard, 2004: 225-227). Once the mean values associated with each and every event has been calculated, then the standard deviations around the mean values will be estimated to produce a confidence intervals around the mean values representing the tolerance of the system to positive and negative impacts. The larger the value of standard deviation, the larger will be the interval and hence the higher the expected risk (Pritchard, 2004: 233).

Under PERT, the events which yield very small or insignificant standard deviations are treated as risk free activities. On the other hand, it is the task of the risk manager to identify the areas where risks are estimated to be high and allocate more resources in reducing the risks. A chart which is derived from PERT is referred to as Critical Path Method (CPM) which is easier to read and interpret in dealing with risk management relating to different events or activities. The application of PERT in deployment and effectiveness of CCTV surveillance system can prove to be beneficial as the risk prone areas are targeted and then more cameras or better equipment are installed in such places to increase vigilance and reduce the risk of crime.

Another technique used in day to day management is SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. Although this technique has been widely used to compare one firm with another in a given industry, SWOT analysis can help identify the low crime areas with high crime areas and then identify what threats emerge with such place and how to search for opportunities to reduce crime (Pritchard, 2004: 151-154). For example, in the UK the weak or most risky areas have been identified as small and enclosed places in city centres. Accordingly, it has been suggested that such places must be fully policed through use of CCTV surveillance system as well as physical presence

of the police force. The threats part of SWOT could come in form of risk and uncertainty which can be partly removed or reduced if sufficient resources are allocated for such purposes. On the other hand, the opportunities may come through use of more advanced and workable technology or recruitment of more qualified and trained staff.

A more generalised version of SWOT is PESTEL (Political, Economic, Social, Technological, Environmental, Legal), representing political, economic, social technological, environmental and legal considerations. This type of approach covers both internal and external factors affecting the deployment of CCTV surveillance system. In the case of decisions for deployment of CCTV cameras the most influential factor is social pressure, followed by technological factor. Indeed, economic factor can play an important role here as costs of deployment and maintenance of CCTV cameras can be a deterministic element in decision-making.

Finally, as another useful means of managing a project, KPI (Key Performance Indicators) is usually used in businesses. The typical KPI in the case of CCTV surveillance system is effectiveness of the system in curbing and reducing crimes. The effectiveness of CCTV deployment can come either in the form of cost reduction or benefit generation. For example, most studies in the UK have shown that since the installation of CCTV cameras in city centres, all types of theft have been reduced significantly. On the other hand, a study by Keval and Sasse (2010), has attached much greater weight on communication among staff in control rooms as an important KPI. Based on a structured observation and semi-structured interviews of 13 managers and 38 operators at 13 control rooms, they reported that lack of communication among the members of control rooms had led to a number of failures including poor technology configuration, poor quality recordings, and lack of system integration.

On specific issues relating to risks and risk management of CCTV surveillance systems in Saudi Arabia, several points must be made reference to. Before any further extensive deployment of CCTV systems in the country, the government decision-makers, with the help and advice from their counterparts in business corporations, should move towards building a comprehensive set of regulatory measures. Such legal stature should be developed in line with the current and future deployment of CCTV, as well as it would carefully incorporate the highly sensitive cultural, religious and human rights issues. Secondly, as identified earlier, the role of supervisors in ensuring effectiveness and fairness must be treated as paramount. A program of continual management and supervision training primarily designed for CCTV systems management need to be

introduced to make staff aware of their sensitive responsibilities in dealing with the public.

In the case of the deployment of CCTV technology in Saudi Arabia and as the study has demonstrated, , the potential risks tend to emerge from the control rooms supervision. Once an effective legal structure is in place, it is anticipated that through efficient supervision and staff training risks will be reduced significantly The details about training programmes and their potential effectiveness will be discussed later in this chapter.

5.2.3 Legal Aspects

As has been repeatedly stated and examined, one of the most critical aspects of decision-making relating to an implementation and deployment of a CCTV surveillance system is to convince people about the usefulness against its possible legal and privacy issues. The previous chapter showed that the main sources of opposition to deployment of CCTV in Saudi Arabia is the result of a combination of people's lack of education and knowledge of CCTV, religious/cultural backgrounds, and lack of trust to CCTV controllers. However, more importantly, the justification for deployment of any surveillance system must be made by conducting a comprehensive research on legality issues.

The current regulations and laws surrounding CCTV surveillance systems are primarily based on data protection laws and hence there is a need to perform some significant research and enhancement to be made to improve such laws to meet the ever growing surveillance systems. The earlier study by Norris and Armstrong (1999) presented a number of cases where the civil liberty of citizens has been ignored in favour of deployment of CCTV systems which have later proven to have been ineffective in crime reduction. This study relates to an extreme case where the CCTV deployment has produced not only heavy costs of installation and maintenance but also massive social costs as privacy of citizens has been adversely affected. The issue of privacy and civil liberty has also been discussed in Gill and Spriggs (2005) as they make special references to cases where the social costs arising from deployment of CCTV have significantly exceeded the social benefits.

For effective and workable regulatory measures in support of deployment of CCTV surveillance systems, as suggested by several authors, decision-makers should invite feedback and support from the people who may be the subjects of surveillance. This process is normally conducted and discussed by members of parliament in parliamentary democracy. However, in large number of countries, in the absence of such facility, local

communities need to be contacted to offer a platform in which they could express their views and concerns about surveillance.

Qatar, for example, has been one of the forefronts of introducing a number of regulatory measures governing the use of CCTV surveillance since 2011. In addition to recommending all the government offices and organisations to be equipped with the latest versions of the CCTV technology, it has gone further to make it compulsory for all small and large businesses to follow a number of procedures in regard the use and management of their CCTV surveillance system. In particular, the law enforces that businesses must have a control room with 24 hours surveillance facility. Furthermore, it recommends that recordings to be kept for 120 days and that the footage not to be altered before being handed over to competent government departments if requested. The law clearly states that if any business is found to violate these mandatory regulations, they could face up to three years in jail and fines of not less than $10k, and in some cases it could lead to the cancellation of their business licence (Doha News, 2014).

Similarly, in the UAE there are various laws and regulations which protect fundamental human rights, such as the right to one's own image as well as the right to privacy and confidentiality. However, none of these laws tend to allow for the recording and processing of information through CCTV, particularly in cases where there has been no consent. According to GlobalHub (2014), the current legislative are old and go back to the UAE Constitution of 1971 for protection of individuals against offences and punishments for publication of private matters or the unauthorised disclosure of private information. Nevertheless, such laws need to be enhanced and further developed for the cases where CCTV surveillance system is concerned.

In the case of Saudi Arabia which closely follows the Sharia Law the justification of legality of CCTV deployment has particularly proven extremely challenging. Several studies that were examined in the Literature chapter were all indicative of the fact that a complex mix of cultural and religious values are responsible for low acceptance rates of surveillance systems in Saudi Arabia. Against this background, such studies have, nevertheless, admitted that people are now becoming aware of the fruits of CCTV system as businesses have managed to fight and reduce theft, and hence been able to protect public morality. Such feedback and support for CCTV surveillance system by small minority but highly educated and economically-active people tends to favour further deployment of such facilities in the kingdom. Despite all these awareness, to date no serious attempt has been made by the authorities to expand and extend the Articles 26 and

38 of the Saudi Constitution – human rights and individual protection laws - to the specific deployment and use of CCTV surveillance system. For example, to highlight the problem of face recognition and other means of identification facing the CCTV control room operators, Al-Lily (2011) has argued that in the future when more of such communication and surveillance means are introduced, the conservatism and protectionism of women will be loosened, giving way for more effective and extensive implementation of the technology. On the whole, in relation to legal structure for CCTV surveillance systems in Saudi Arabia, it can be said that to date no comprehensive national legislative framework is in place to address and clarify the concerns, questions and mismanagement issues that are currently unanswered.

In the short run, as the decision-makers in Saudi Arabia are engaged in developing a carefully designed set of regulatory measures for CCTV surveillance in line with the Sharia Law, it is recommended that some codes of practice to be introduced for staff in all aspects of security. The so-called 12 guiding principles designed by the UK government appear to be a good starting point for the Saudi security departments to apply (ICO, 2013). These 12 principles are as follows:

i) The use of a CCTV camera system must always be for a specified purpose with a valid aim of preventing crime.
ii) The use of a surveillance camera system can always have indirect effect on individuals and their privacy, which has to be carefully considered and reviewed periodically.
iii) Transparency must always be exercised in all situations when using a surveillance camera system, free from any personal or private gains.
iv) There must be clear responsibility and accountability for all surveillance camera system activities including images and information collected, held and used.
v) It is the duty of the managers or supervisors to offer clear rules, policies and procedures prior to use and deployment of CCTV cameras.
vi) There should be a certain period for which images and other information is stored, and after that period all such information must be destroyed.
vii) Any access to stored images and information should be restricted; and the disclosure of images and information should only take place when it is necessary for such a purpose or for law enforcement.
viii) The CCTV system operators should be fully trained and certified to deal with operational, technical and competency standards relevant to a system

ix) Surveillance camera images and information should be kept safe and secure to safeguard against unauthorised access and use.

x) There should be periodical review and auditing system in place to ensure all legal standards are fully complied with in practice.

xi) CCTV surveillance cameras should be used in the most effective way to support public safety and law enforcement with the aim of safeguarding the public.

xii) All information used to support a surveillance camera system should be accurate and kept up to date.

5.2.4. Technical Applications

As it was argued in the previous chapters, the choice of technology plays an important role in the success or failure of deployment, implementation and outcome of a CCTV surveillance system. This could result from the choice of cameras, location of CCTVs, the location of control room to the use of up to date computer or automated software. As the application of video analytic for surveillance has now reached a new high, the rapid proliferation of CCTV cameras in Saudi Arabia's public areas such as roads, shopping malls, airports, ports, sensitive industries, hospitals etc. The deployment of automated number plate recognition (ANPR) on major motorways has effectively served the country for many years now.

Being one of the forefronts of application of new technology, the Saudi government has, for many years, been promoting the use of advanced surveillance systems. However, according to Said et al (2007), the rate of technology acceptance by the public has been registered as relatively low compared to the European countries. Nevertheless, as explained previously, most public places in Saudi Arabia are now equipped with cameras of the type PTZ (pan, tilt, zoom) within the CAT5 and CAT6 infrastructure. According to Gill and Spriggs (2005), PTZ cameras appear to be more likely to be monitored as operators could control with overlapping fields of vision. An advantage of PTZ over the other cameras is that they can be seen to be moving, hence giving some kind of reassurance to the public that the cameras are really in working and operational conditions.

To further address the issue of secure transfer of video data, the Saudi government should also attempt to incorporate VPN (Virtual Private Network) technology. Under this method a private tunnel is virtually created for the transmission packets with streaming through VPN tunnels which are then securely passed through different paths to the

destination. This method of deployment is particularly helpful in Saudi Arabia where many people have negative views about CCTV systems. In meeting both the speed and the accuracy, a face detection method integrating the skin color segmentation and Split up Sparse Network of Winnows (SNoW) are also becoming available. This method can inherit their common advantage of fast speed by detecting human face areas and then track human face areas.

Saudi Arabia CCTV market has been dominated by analogue based CCTV systems, which tends to account for majority of world-wide market share; however this technology is being phased out and the country's CCTV market is witnessing a gradual shift towards IP based CCTV systems due to growing IP infrastructure in the country coupled with various benefits offered by these systems. The Central region in Saudi Arabia holds the largest market share, in terms of revenue, with major cities such as Riyadh, Jeddah, Makkah and Medina driving the country's CCTV demand. According to Mexory (2015) technology improvements and adoption such as emergence of Network/IP based CCTV systems and various other advancements in terms of cameras, software, and storage devices are expected to further support the market's growth trajectory.

To achieve speed, accuracy, and in line with the existing infrastructure in Saudi Arabia, the study proposes that the decision-makers, be they the private entrepreneur or government agents, to further invest in the SNoW technology within the Network/IP based CCTV surveillance systems.

5.2.5. Certification and Training Requirements

As the Analysis chapter revealed, one of the main sources of concern about CCTV surveillance system in Saudi Arabia is associated with lack of trust to staff in control rooms. The analysis showed that nearly 85% of respondents were of the view that due to lack of ethical concerns, training and supervision the control room staff could abuse their power. It was suggested in that chapter that in order to change the people’s perception about the trust to the system and staff a comprehensive training program at different stages covering a wide variety of courses must be designed and offered to all staff in charge of legal/ethical issues, installation, monitoring, control, and supervising/managing.

Surprisingly, when respondents asked about the effectiveness of CCTV systems in reducing crime and on its general reliability, a large majority were positive that on the

whole the system is reliable and can help improved security and crime reduction. However, their concern about controllers stemmed from the perception that such staff may abuse the pictures and video footage, hence invading their privacy.

In the light of the evidence from the Saudi case studies it is clear that a thorough and continuous program of education directed towards all staff in charge of CCTV surveillance system should be encouraged. For their effectiveness, short duration and least costly GNVQ (General National Vocational Qualification) courses are expected to offer the relevant information and expertise from managerial to installation of CCTV systems. In particular, educating the staff in control rooms can prove to help improve the perception that the public hold against them. Furthermore, the courses in supervision of CCTV control rooms can provide the ethical issues required by the staff to improve their current status. In addition, training on short term basis have already commenced in most public and private institutions in the country aiming to tackle the technical and managerial aspects of CCTV surveillance system.

In addition to these rather long term training programs, there are a number of short courses some as fat short ones which can take place in one day, particularly designed to make staff of all kind to become aware of ethical issues at work and responsibilities to the public at large. In addition to a large number of courses in technical elements of CCTV, there are also one-day online courses on legislation and regulation aspects of CCTV surveillance system primarily designed to suit all staff working within the surveillance and security systems (Tavcom, 2015).

5.2.6. Government Protocol and CCTV Systems

The development of a national protocol for deployment, installation, maintenance and management of CCTV technology is primarily a task for a responsible government. This protocol not only should include clear set of standards, rules and regulations in all aspects of decision-making process, it must also provide all parties with the potential ethical issues arising from use and application of CCTV. Theoretically speaking, a perfect case in development of such a protocol should be based on a genuine public private partnership, where all private and social costs and benefits of the projects are identified and evaluated. This process is analogous to a typical cost-benefit analysis where due to its potential sensitive nature, much greater weights must be assigned to social indicators.

As has been repeatedly stated, in the case of the Saudi Arabian CCTV surveillance is concerned major problem areas were identified in relation to ethical and etiquette issues. The Analysis chapter clearly identified that the general perception of CCTV surveillance is one of serious concern about the possible misuse and abuse of video footage by controllers. Under these circumstances, as common sense prevails, a comprehensive program of staff certificated training must be incorporated within the protocol for both public and private sectors employees. The protocol should include a clause enforcing the compulsory attainment of the relevant certificates for staff - public and private - particularly those involved in control rooms. It has been suggested that for the case of Saudi Arabia, a centre of excellence should be developed to closely follow these standards, training programs, and intervene, monitor and inspect the performance of CCTV management on periodical basis (Robinson, 2012).

This centre of excellence, ideally speaking, should have members from different layers of the society including, economists, councillors, lawyers, engineers and some representatives of the government, and that a realistic annual budget to be determined for the centre. Furthermore, it is anticipated that such a centre of excellence would ensure that all technological advancement in CCTV and other surveillance systems are carefully studied and examined prior to being recommended to the decision-makers. Therefore, in achieving this sensitive objective, a nationally publicised technology related courses and certificates must be made available for those wishing to develop their careers in surveillance systems. In the nutshell, the role of the centre, in so far as technology goes, is one of the promoter of enhancement of training programs in all aspects of CCTV surveillance.

As it was identified and examined carefully in the previous chapter, one of the most important determinants shaping the concern about and the fear of CCTV surveillance systems is associated with the lack of knowledge and understanding of the public about the potential usefulness of the system in protecting citizens against all types of threats. The centre in charge of all decisions about CCTV deployment and management must initially allocate a significant portion of its budget to develop periodic short courses in different parts of the Kingdom in providing basic knowledge of CCTV to people, hence attempting to change the current negative perception of the public of CCTV surveillance system.

One of the greatest benefits of having a proper protocol and an efficient centre of excellence for CCTV surveillance is that such a network of experts can gather valuable

statistics across the Kingdom about the previous cases of deployment, their success or failure and on these bases be able to minimise risks attached to the current and projected CCTV programs. In maximising its effectiveness in reducing or eradicating crimes and providing more comprehensive set of statistics, it is recommended in Robinson (2012) that a centre of excellence, as the guardian of the CCTV protocol, to establish offices in different regions of the Kingdom, enabling them to be of service to their respective local people.

5.3 Practical Implications

When examining the practical aspects and implications arising from deployment of a CCTV surveillance system two main issues are worth considering. The first is the future design and developmental aspects of CCTV deployment in relation to cultural, legal and other socio-political considerations. The second issue covers the teasing subject of governance and long term CCTV developmental programs.

5.3.1. Design Aspects of Development

The deployment of CCTV surveillance system in Saudi Arabia has so far created concern and reservation about its effectiveness and value for money. The general perception about its crime reduction ability may be positive but there is generally opposition to its presence in public places. The marriage of advanced technology and deeply culturally and religious bounded society is a delicate one and needs to be thought over extremely carefully. The government of Saudi Arabia has so far been able to delicately handle the issues relating to the deep rooted culture and religion in so far as the deployment of CCTV surveillance system goes.

Advancement of technology has enabled the deployment of sophisticated and concealed cameras in public places. Furthermore, in the near future when the drone technology is fully standardised, the movable CCTV surveillance would make deployment much easier, as decisions about where to locate cameras will become irrelevant. However, what matters seems to go beyond technical ability and financial constraints surrounding implementation and deployment of CCTV surveillance system. As stated earlier, the design of CCTV surveillance and its future development strategies must be closely in line

with public demand and environmental determinants. The most critical environmental factors are religion and culture which shapes the Saudi life.

As stated before, against all these cultural and traditional values, the Saudi public may well accept further installation and deployment of CCTV surveillance systems all over the country provided they are perceived that the systems are fully managed and that there is no abuse of the system by anyone. The findings from the three case studies offered in the previous chapter suggest that the serious matter raised by a large proportion of the respondents relates primarily to management/supervision of CCTV rather than privacy issues. Even the awareness about the privacy invasion, brought about by a significant portion of the respondents, appeared to relate to the possible abuse of the video footage by male controllers.

In order to implement and deploy a successful program of CCTV surveillance system, the Saudi government should proactively consider the following sensitive issues and attempt to find ways of achieving them:

i) Following the findings from chapter five, it became evident that the respondents attach much greater concern and attention to the possible abuse of evidence from CCTV by controllers. To overcome this problem, several strategies need to be adopted. First, education and awareness program for controllers must include ethical and managerial responsibilities and accountabilities. Secondly, the recruitment and training of female controllers can help improve this situation significantly. Finally, as the findings of the previous chapter showed, the number of hours of supervision and weekly frequency of all recorded footage were minimal and poor. This is the job of the project or risk manager to make sure that the frequency of supervision and quality of service to increase in order to reduce any likelihood of abuse by controllers.

ii) As the results of the Analysis chapter showed, an individual with either have no educational qualification or no knowledge of CCTV could have the probability of around 70% of becoming opposed to CCTV. On the other hand, an individual with high level of educational attainment and high knowledge of CCTV has only 43% chance of opposing to CCTV, some 37 point percent lower than the former group. It is therefore clear that provision of accurate and straightforward knowledge about CCTV technology and its potential benefits can help reduce concern about CCTV significantly. Such a strategy

should be promoted and financed by the Saudi government, helping to weaken the current state of concern about CCTV surveillance systems.

iii) Saudi people are very sensitive to safety and security issues, particularly those relating to the prevalence of terrorism. Despite a number of opposition to deployment of CCTV cameras in the holy city of Makkah, the logical argument made by the government in relation to issue of safety, it managed to defeat the opposition. Similar initiatives based in safety and security have been won by the government in past simply because the public have realised that the security risk were much greater than other risks associated with CCTV management.

5.3.2 Governance and CCTV Development

Although the deployment of CCTV across Saudi Arabia initially appears to be unregulated, it is apparent that common approaches to the installation and use of CCTV systems have emerged and in effect regulate the technology. For a new technology like CCTV, the emergence of regulation is closely related to the process of technological diffusion (Webster, 2004). Although the Saudi regulatory measures governing CCTV surveillance system is taken primarily from those of the UK and the European standards, there is now a need for a domestic set of regulations to emerge representing the cultural values and traditional values of the citizens.

Governance is all about governing or managing a number of projects and activities efficiently and equitably. It all boils down to doing things with responsibility, accountability and transparency considerations. As far as CCTV surveillance system is concerned, the government should propose a concise and clear series of documentations and recommendations about the process of its implementation and deployment. The document should clearly show which areas are to be affected, giving the true costs and benefits of the deployment. Such documentation must also present some future developments along with their costs and benefits and processes of managing them. These documents must be available for the public to see and offer their feedback.

Although the Kingdom has already developed a number of documents outlining standards and rules and regulation on CCTV surveillance system, such documents fail to fit within the theoretical framework of a good protocol. As discussed in the theoretical part, the government should aim to establish a centre of excellence for the CCTV surveillance

protocol. This centre must be fully in charge of all decisions in relation to deployment, and day to day management of all CCTV systems in the Kingdom. This centre, as stated earlier, must be given a respectable budget to proceed with its delicate task of educating the public, providing training programs for staff, evaluating the true costs and benefits of any deployment project, measuring the actual effectiveness of projects and finally collecting and compiling useful statistics for future calculation of risks and uncertainty arising from new projects. To provide the services the centre should be headed by an Director to report to the government (perhaps affiliated to the ministry of skills and technology) and supported by a Technical Director including a General manager to oversee operational activities. The Technical director should manage all technical activities including training needs and keeping pace with the fast development of the technology.

As for the case of a CCTV surveillance system which requires advanced technology and IT support, the so-called IT Infrastructure Library (ITIL) represents essentially a series of documentations that are made available by government to offer aid in implementation of a long term IT services framework (Axelos, 2015). A proper ITIL is expected to come in a series of five volumes: Service Strategy, Service Design, Service Transition, Service Operation and Service Improvement. Service Strategy includes the main activities such as the market definition, assets and execution processes, aiming to build a cost effective technology based strategy. In so doing, it provides the right balance between performance and cost. Service Design, on the other hand, design IT services in alignment with Service Strategy, by defining how technology services to be built. Service Transition is all about management and support for a number of important elements shaping the deployment and the management of transitional planning and support, with the output being the applications. Service Operations is all about delivering and managing services at the agreed levels to business users/customers. Finally, Service Improvement is about prioritizing and initiating improvement in projects, with the aim of offering better metrics of all IT processes - value for money, hence superior application of IT services.

Together these five volumes represent a network of long term plan, describing a closed loop feedback system that provides feedback throughout all areas of the life of project. These volumes are there to provide a framework of best practice disciplines that enable IT Services to be provided effectively. In order to make stakeholders be aware of and understand the benefits of ITIL a process of a comprehensive certification scheme enables individuals to participate and receive the ITIL Foundation Certificate.

A similar ITIL can be constructed for all other aspects of CCTV (decision-making, installation, choice of places, maintenance, supervision, risk management) producing documentation for all areas of surveillance. Similarly, in making staff and other stakeholders to become aware of the content of the volumes, a number of programs must be developed to offer short courses leading to certification.

Any IT management programs will fall within the framework of CCTV surveillance system. The so-called COBIT (Control Objectives for Information and Related Technology) is one of the frameworks devised for IT governance and management. It is a supporting tool set that allows managers to bridge the gap between control requirements, technical issues and business risks. In the nutshell, COBIT aims to conduct research, develop, publish and promote an authoritative, up-to-date, international set of generally accepted IT for day-to-day use by, IT and associated managers and professionals.

The COBIT framework supports governance and hence it can be incorporated into CCTV surveillance management system CCTV by defining and aligning the goals, as COBIT provides a set of recommended best practices for governance and control process of information systems and related IT activities. COBIT 5 for example is a consolidation of COBIT4.1, Val IT and Risk management into a single framework acting as an enterprise framework aligned and inter-operable with TOGAF and ITIL.

Finally, another recently developed method of training and certification, referred to as PRINCE2, designed initially by the UK government, is becoming popular internationally as an excellent model of management and supervision training scheme. PRINCE was originally based on PROMPT, a project management method created by Simpact Systems Ltd in 1975, and the later adopted in 1979 as the standard to be used for all Government information system projects in the UK. PRINCE was launched in 1989, superseded PROMPT within Government projects. PRINCE remains in the public domain and copyright is retained by the UK government. PRINCE2 was published in 1996, having been contributed to by a consortium of some 150 European organisations.

As a part of its extended managerial training, the government of Saudi Arabia can adopt a version of this program for the managers and supervisors working within the general security and surveillance departments. Because of its management content covering, among other things, a number of issues relating to etiquette and ethical issues at work, this program may be of great interest to supervisors in charge of the control rooms of CCTV cameras.

As an additional aspect of governance of CCTV, in a recent move by the Saudi government, a decree was passed that as of early 2015 there would be CCTV cameras coupled with a smart control system to monitor the Imams and the Muezzins (prayer callers) as they perform prayers, religious rituals and deliver sermons. According to the government, in the light of increased tension this move can help record any irregularities or violations in the mosques across the country. Given the extent of the expenditure required to meet this project, funds will be made available to Ministry of Finance to proceed with the first stage of the implementation in the large mosques across the Kingdom followed by the smaller ones, in the second stage (Arab News, 2014).

5.4 Research Theoretical Framework Validation

As has been reiterated in Noble and Smith (2015), any research project based on surveys involving people need to be validated as a part of evaluation of the quality of research findings. Without validation of the data/information collected and evaluated, any recommendations or policy implications arising from the research cannot be fully trusted. In the words of Creswell and Miller (2000:124) validity is a process of determining to what extent "the account represents participants' realities of the social phenomena and is credible to them."

It is fair to argue that the complexity attached to validity in research is primarily associated with researcher's perception, and the choice of assumptions made (Creswell and Miller, 2000). Therefore, depending on the methodological approach chosen, different validity processes need to be furnished. Although many authors and researchers (for example, Golafshani, 2003; Bryman, 2008; Noble and Smith, 2015) tend to attach validity merely to qualitative investigation, any research based on survey data/information should follow a coherent validation (Hammersley and Atkinson, 2007).

To validate findings of this study a number of procedures and steps have been undertaken to ensure that the research outcome is sound and reliable. These steps can be summarised as follows:

(i) Researcher's prior knowledge

Prior to undertaking this research, the researcher has been involved in studies and working on CCTV installation and technological issues relating to surveillance systems in the

Kingdom of Saudi Arabia. Furthermore, once engaged in the PhD research programme at Northumbria University, the researcher gained access to a massive amount of literature and relevant theoretical frameworks which enabled him to develop the means of examination and analysis of issues surrounding a large number of social, economic, political and technological determinants of surveillance systems.

(ii) Consultation with academicians and experts

In addition to learning and absorbing information through published work and previous research investigation, the researcher became engaged in making contacts with a number of academicians in both KSA and the UK in order to understand the practical aspects of data collection and the contents of the survey. Furthermore, the researcher had lengthy discussions with experts and decision makers in this filed in KSA in order to identify the most relevant, sensitive and practical aspects of CCTV surveillance systems. In addition to the above meetings and discussions, the researcher and the principal supervisor had a formal discussion in Riyadh (KSA) with the Hospital stakeholders to discuss various aspects and requirements including a potential deployment of the technology in their institution.

The feedback received from the participants from the questionnaires and further contacts established with a number of academicians through these conferences provided the researcher with an immense knowledge and awareness of problems and challenges in surveys and analysis of data/information.

(iii) Conference Attendance

In addition to the above engagement, the researcher was proactively involved in attending and presenting papers in a number of conferences of which the last three are as follows:

- The ICEMESCT – International Conference on Entrepreneurship in Management, Education, Science, Computing and Technology, in Istanbul, Turkey, 18-20 May, 2015.
- First International Conference on Anti-Cybercrime (ICACC-2015), in Riyadh, Saudi Arabia, 10-12 November 2015.
- The IEEE International Symposium on Multimedia (ISM), in Miami, FL, USA, 14-16 December, 2015.

- International Conference on Science, Arts, Business and Education 25 th -26 th December 2016 Paris – France.

The feedback received from the participants from the conferences and further contacts established with a number of academicians through these conferences provided the researcher with a immense knowledge and awareness of problems and challenges in surveys and analysis of data/information.

(iv) Focus Study Group

Finally, given all the information and knowledge accumulated through the above steps in the research, the study proceeded with development of a short but appropriate questionnaire for the means of conducting a focus study group. This has included end users, academics, and the sponsor where each group were represented by 3-4 people. The findings were discussed and analysed to map the expectations and achieved results from the view point of deployment strategy in relation to the constraints as specified at the early stage of the project and then refined later on. The feedback received from the participants and others who had the chance to examine the questionnaire was extremely beneficial in helping the researcher to develop the final version of the framework.

5.5 Summary

This chapter has discussed the framework proposed in this study. The discussion has targeted the theoretical and practical aspects arising from the deployment of CCTV surveillance system in Saudi Arabia. On the theoretical side, references were made to its deployment, risk management, legal aspects, technical, training and certification, and government protocol. On the practical side, two main and general points raised: design and governance.

The examination of risk management has revealed that a number of techniques can be employed to efficiently identify and measure risks associated with every event within a project. In the case of Saudi Arabia, in relation to the findings of chapter five, most risks appear to be in management and supervision of the control room. In the case of technology used, it was noticed that the country benefits from application of highly advanced CCTV technology. However, it was suggested that the advancement of technology should go in line with training and education of staff in charge of day-to-day maintenance and management of CCTV surveillance system.

In the light of findings, the chapter concludes that certain areas in relation to CCTV surveillance system in Saudi Arabia need to be carefully reconsidered. Firstly, when making people aware of the benefits of CCTV system, the government should offer a continuous awareness education to all people as lack of knowledge of CCTV appears to be a fundamental factor in opposing the surveillance system. Secondly, the public must be ensured that there would be no place for controllers to abuse the CCTV footage. Similarly, a number of courses must be designed and delivered to all control room staff about the ethical issues and their accountability in dealing with CCTV evidence. Finally, the government must realise that if the information about security and risk to people's lives are properly channelled to the public, then there could be less resistance to CCTV deployment.

As a summary, the framework has identified and examined a number of issues and subjects for discussion and evaluation which can help the research to come up with more comprehensive set of solutions to the teasing question of CCTV deployment.

CHAPTER 6: ADVANCED CCTV TECHNOLOGY: EXPLORING APPLICATIONS

6.1 Introduction

In this chapter, we will review and explore some applications of the advanced CCTV technology such as automatic age estimation, motion tracking, gender recognition, gait recognition, heterogeneous face recognition, person's re-identification, action recognition. These tasks are important problems encountered in telesurveillance applications. These can be incorporated gradually depending of the requirements into an automated CCTV telesurveillance system.

6.2 Automatic human age estimation

Automatic human age is the task of automatically estimating the age group of an individual with the help of automatic computer algorithms. The task of human age estimation has recently become a very active area of research. The benefits of automatically identifying the age of an individual from images or CCTV feeds justify this increase in research. The advantages include but are not limited security control, advertisement surveys, age restriction applications. For example, automatic age estimation can ensure that children do not access adult websites, similarly age estimation can be utilised in vending machines to ensure no age restricted item is sold to under aged individuals, also age estimation applications can be used to monitor which age group spends the most time viewing an advertisement. Although, age estimation can have useful

applications, it still faces un number of challenges since the problem is not a simple classification problem but a regression problem, too. For example, authors [Yun and Huang, 2008] and [Geng et al, 2007] demonstrated that the age progression of a person is very personalised and is different for every individual and such changes are very difficult to capture in automatic estimation systems. These problems confuse the classifier and this leads to misclassified subjects.

Methods of age estimation can be divided into three categories;

(i) Anthropometric models - These systems depend on a classification based on the facial skin wrinkles of the subjects [Kwon and Lobo, 1999]. These methods are suitable for very broad age estimation such as infant, teenager, middle aged and old. Methods such as these are at times used before the more advanced methods in order to increase the interclass distance and decrease the intra-class distance.

(ii) Pattern subspace - This method relies on projections in subspace that can be used to reconstruct facial images. This method is utilised in cases of incomplete datasets [Geng et al, 2006].

(iii) Age regression - In the regression method facial features are extracted from a shape texture point of view and then represented using parameters from a fitted model. The regression functions are then estimated using a known regression function. This method is used for a more accurate age estimation and is used to further narrow down the ages after anthropometric methods [Yan et al. 2007].

In recent years there have been quite a few methods proposed for estimating the age from a multi-classification point of view. Guo and Mu (2010) proposed a technique for age estimation and gender estimation showing that it can be helpful as males and females show indications of age differently. Based on this concept the authors generated a framework of age estimation following gender estimation process. Similarly the authors in [Guo et al, 2009] realised that age estimation suffers as the database size increases (as would be in a real world scenario) so the authors developed a manifold learning method for estimating the age of individuals from a large learning set. Dong et al, (2012) further improved on the previous results by using a ranking SVM method for age estimation. The author made the assumption that the features used for facial recognition can also be used for age estimation with very good results, so first using face images from a database the

rank relationship is established and then using this rank relationship the age is estimated using the age information from a reference set.

6.3 Motion tracking

The idea of machines automatically tracking individuals has given rise to research in the field of automatic motion tracking. The goal is to automatically segment a person from the surroundings and to track the motion of the said individual. This concept can be applied in a wide variety of domains such as security surveillance, child/elderly monitoring, home monitoring etc. Motion analysis is of specific importance as it can be used in applications such as virtual reality, human and robot interaction and computer gaming.

The concept of motion tracking has been under active research from the 1960's [Chen et al, 2013] and has quite a few challenges associated with it such as environmental conditions, privacy and also by the fact that the acquisition of data is done with the diversity of the human body in terms of size, shape, movement, clothing which make the process of automatically recognising and tracking human a challenging task.

Work on motion detection and tracking has been performed with some attractive results. However, due to changing environment conditions video can be noisy, blurry thus making the process very difficult especially to model and subtract the background from the subjects/objects [Aggarwal and Ryoo, 2011] , [Ji and Liu, 2010].

There have been advances in the field of motion tracking. Urtasun et al. (2006) tackled the problem of automatic human tracking using a Gaussian Process Dynamic Model (GPDM), the authors incorporated nonlinear Gaussian processes with the help of dimensionality reduction methods and showed significant improvements in human tracking over previous published methods. Dimensionality reduction procedures although effective, proved to be a challenge as they could not be applied to composite motions. This issue was addressed by Pavlovic et al. (1999) by proposing switching dynamic systems where a switching variable effectively and accurately switches over various motion dynamics. Zhou et al. (2003) proposed for the purpose of simultaneous tracking and recognition a probabilistic approach of tracking and recognising simultaneously the human faces from a video stream. Aside from GPDM Gaussian Process Latent Variable Model (GPLVM) proposed by Lawrence (2005) is also an effective method of

representing a high dimensional space in a compact dimension. The GPLVM method has been used effectively in automatic human tracking [Urtasun et al, 2005].

6.4 Gender Recognition

Identifying the attributes of humans such as gender using computer vision is very important and has been the focus of research over the past few years. Gender determination can play an important role in applications involving human computer interaction, surveillance, targeted advertising etc. Research suggests that human beings can easily differentiate between males and females (at least about 95% of the time) [Bruce, et al, 1993]. However, for computers it has proven to be more of a challenge to automatically identify the genders from a video or image source. The fact that gender identification must be nonintrusive, unlike iris or fingerprint analysis, has also contributed to this difficulty.

The challenges faced by gender classification in computer vision is due to the vast variation of the human faces. Problems such as age impact, occlusions, pose variation and facial expressions are all important factors to consider in gender classification. The pose alone has three different variations; described by the roll, pitch and yaw angles [Murphy-Chutorian and Trivedi, 2009]. The age impact has been widely observed. Benabdelkader and Griffin (2005) performed their analysis on a database of 12,964 facial images and determined that their classifier was failing the most on a large number of young males and elderly females. On the other hand, the work described in [Guo et al, 2009] showed that gender classification is greatly affected by age as their classifier was showing higher accuracy for adults but a smaller accuracy for young faces.

Most applications dealing with gender identification break down the process into multiple steps such as segmentation, feature extraction, and then finally classification. In segmentation pre-processing is employed such as identifying the face area, and then normalization procedures such as illumination adjustment is undertaken [Viola and Jones, 2004]. Some processes perform gait analysis in this step, where a binary silhouette of the subject is extracted using background subtraction. The more successful methods depend on the histogram of gradients (HOG) for the purpose of human detection in the source such as in [Dalal and Triggs, 2006].

The feature extraction stage tries to best capture the features of the pre-processed and identified areas of the image or video feed. Features such as rectangular features [Viola

and Jones, 2001], Local Binary patterns (LBP) [], Scale Invariant Feature Transforms (SIFT) [Ojala and Pietikainen, 2002] and Gabor Wavelets, especially the 2D Gabor [Lee, 1996] have shown to work best with Gender classification.

Finally, after preprocessing and feature extraction the classifier is trained using with the features extracted. Gender analysis is a problem best solved by considering it as a within-object problem of classification [Aghajanian et al, 2009]. The classification in Gender analysis is much simpler than other fields of classification where more than one object is to be identified, but since gender classification deals with identifying only two objects (male or female) a binary classifier can be used. Classifiers such as SVM [Jain et al, 2005; Lee et al, 2010; Li et al, 2011], SVM-RBF [Buchala, et al. 2005; Wu et al, 2011], Bayesian [Demirkus, et al. 2010] and Spatial GMM [Li and Jhou, 2009] have been most commonly used with classifying gender.

6.5 Gait recognition

Gait recognition has emerged as a powerful biometric technology which aims to identify people purely through the analysis of the way they walk. The technology has attracted interest as a method of identification because it is non-invasiveness since it does not require the subject's cooperation. However, "covariates" which include clothing, carrying conditions, and other intra-class variations affect the recognition performances. Gait recognition techniques can be classified into two main categories: model-based and model-free approach. Model based approaches [Yam et al, 2004; Niyogi and Adelson, 1994] model the person body structure and is based on the estimation over time of static body parameters such as the trajectory, limb lengths, etc.). This process is usually computationally intensive since we need to model and track the subjects body. On the other hand, model free approaches do require the extraction of the resulting structural model of human motion. Rather they use the features extracted from the motion and/or shape. If compared to a model based approach, a model free approach is much less computationally intensive while at the same time the dynamic information would improve the recognition performances [Wang et al. 2004]. These reasons have motivated the researchers to introduce new feature representations in model free approach context. The major challenges of methods belong the model free gait recognition are due to the effect of various covariates which are due to the presence of shadows, clothing variations and carrying conditions (backpack, briefcase, handbag, etc). From a technical point of view segmentation and the view dependency are further causes of gait recognition errors. A

number of works have been proposed to address the issues relating to model free approaches for gait recognition. For example, BenAbdelkader et al. (2004) introduced a self-similarity representation to capture the similarity between pairs of silhouettes. Collins et al. (2002) proposed a template based silhouette matching and applied it to some key frames. Recently, the concept of Gait Energy Image (GEI) representation proposed by Han and Bhanu (2006) has attracted interest from various researchers. GEI is a spatio-temporel representation of the gait obtained by averaging the silhouettes over a gait cycle. However, it has been found that the varying clothing and carrying conditions between the gallery and probe sequences can influence the recognition performances [Han and Bhanu 2006; Yu et al., 2006]. To address these limitations several works have been proposed. Bashir et al. introduced Gait Entropy Image (GEnI) by computing Shannon entropy for each pixel over a gait cycle in order to distinguish static and dynamic pixels of the GEI. In this case GEnI represents a measure of feature significance (pixels with high entropy correspond to dynamic parts which are robust against appearance changes). In the same context Bashir et al. proposed later a new gait representation called flow field [Bashir et al, 2009] in order to represent a weighted sum of the optical flow corresponding to each coordinate direction of human motion. An unsupervised method is employed to select GEI pixels using their intensity value [Bashir et al, 2008]. Dupuis et al. (2013) introduced a feature selection method based on Random Forest rank features algorithm. Very recently Rida et al. proposed a supervised feature extraction method based on Modified Phase-Only Correlation (MPOC) [Rida et al., 2014] as well as a feature selection mask based pixels intensity [Rida et al., 2014].

6.6 Heterogeneous Face Recognition for Telesurveillance

Person's recognition using facial images taken from surveillance-quality video based are characterised by (i) variable illumination, (ii) variable pose of the subjects in the video, (iii) the low resolution of the faces in the video and (iv) obstructions of the faces in the video. Such video data is taken at a distance and is usually of very low quality making it difficult for automated facial biometric recognition. For example, faces from CCTV cameras, which are very often partial having low resolution with poor quality, are matched against high quality and high resolution images available in databases. In addition to Pose, Illumination and Expression and Occlusion (PIEO) distortions, appearance difference, feature gap and blurring are other distortions that need to be addressed. In the very early psychological studies on face recognition in poor quality video by [Burton *et al.,* 1999] it was suggested that the challenges for next generation

automatic face recognition is to outperform human level of performances when matching unfamiliar low-quality faces. An appropriate approach to match the low-resolution image to high-resolution is to generate a super-resolution image from its low-resolution counterpart and finally, the classification is applied [Freeman *et al.,* 2000]. A tracking-and-recognition approach in a unified probabilistic framework fusing temporal information and the time series state space model is adopted to characterise the evolving kinematics and identify human faces taken from video [Zhou *et al.,* 2003].

Recently, researchers have increased their effort to solve low resolution image problem from CCTV after several terrorist activities around the world. A pose variability compensation technique, which synthesizes realistic frontal face images from non-frontal views was proposed to detect the pose through a correlation model by modelling the face via Active appearance models [Ting *et al.,* 2007]. In [Hennings-Yeomans *et al.,* 2008] it was reported that matching a low quality image with high resolution one can be done either by up-sampling the probe and down-sampling the gallery. In their technique, they assume super-resolution and face recognition algorithms have been selected in advance. Later on the same authors proposed a new algorithm for recognition of low-resolution faces for cases when multiple images of the same face are available at matching [Hennings-Yeomans *et al.,* 2008]. The first real scenario using CCTV video face images where it was reported that image degradations and mismatch of cameras lead to a serious decrease in recognition [Chen *et al.,* 2008]. Recently, a reconstruction-based super-resolution method was proposed to deal with the real-world problems of super-resolution recognition systems working with surveillance video sequences [Nasrollahi and Moeslund, 2011]. Although good recognition accuracies were obtained, still both databases are generated from constrained and controlled environments. Dadgoster *et al.* (2011) used video analytics specifically designed for automatic enrolment and subsequent re-identification of faces taken from a network of cameras for use as an assistive tool for passenger screening at airports as passengers walk through various sections of the airport. Biswas *et al.* (2013) developed an approach for matching surveillance quality facial images against high-resolution images in frontal pose which are often available during enrolment. However, the technique was not validated against real video data. Very recently, Shaikh *et al.* (2014) proposed a low-to-high resolution video matching technique using a generative probabilistic method which models the face into both signal and noise components. Later on the same authors developed an algorithm where there exists a single

instance of an individual image in a gallery having with high resolution while the probe is captured with alternate modality of a low-resolution.

Recent work at Northumbria University is targeting the completely automatic person's recognition of low-quality faces generated from CCTV using a novel approach which employs. Generalised Gaussian mixture models tailored to represent a generic model to represent both face and scene variability using the concept of multi-scale patch based Histogram of oriented gradient (HOG) analysis. This will exploit the latent identity variables and latent noise model to represent global faces for our Gaussian mixture. We will also address the effect of cameras/sensors/ modalities in heterogeneous domains which may also contribute to the poor performances of previous attempts of automatic recognition.

6.7 Person's re-identification

Person re-identification involves identifying new occurrences of a given subject previously detected at a different location and time across a network of cameras covering a large area by non-overlapping fields of view. Person re-identification has been an active research area especially for telesurveillance applications. For example, re-identification is particularly useful in all the situations in which a large crowd gather, a kind of event more and more common in everyday life due to architectural (tall buildings, huge commercial centres, airports and stations which usually contain several thousand persons) and social reasons (e.g. big entertainment events) among the others. The problem of person re-identification has been studied extensively using both supervised and unsupervised models. In the case of discriminative models [Chen et al., 2015; Dikmen et al., 2011; Hirzer, et al. 2011; Zhao, et al. 2014; Proser, et al., 2010], various approaches can be deployed including classic SVM, RankSVM [28, 40] and boosting [Gray and Tao, 2008; Shen, et al., 2015]. For example, Zhao et al. (2014) proposed to learn the weights of filter responses and patch the matching scores using RankSVM. On the other hand, Gray and Tao (2008) employed a feature selection among an ensemble of local descriptors using the boosting process. Recently, Li et al. (2014) have proposed a deep learning network approach to jointly optimise all pipeline steps. This concept has led to reduce the impact of multi-view variations but at the expense of more laborious annotation, especially when new cameras are added in the system. In the case of unsupervised models, Farenzena et al. (2010) have proposed the use of both symmetrical and asymmetrical nature of pedestrians and proposed the SymmetryDriven Accumulation of Local Features

model. Ma et al. (2012) have employed the Fisher Vector to encode local features into a global vector in order to improve the performances. Zhao et al. (2014) exploited the salience information among pedestrian images and proposed to assign higher weight to rare colours. Other works have proposed an unsupervised method which can be adapted to different camera networks. On the other hand, the field of image search has been greatly advanced since the introduction of the SIFT descriptor [Lowe, 2004] and the last decade, a plethora of methods [Jegou et al., 2008; Zheng, et al. 2014; Zhou et al. 2010] have been proposed to improve search performance. For example, to improve matching precision, Jegou et al. (2008) embed binary SIFT features in the inverted file. Meanwhile, refined visual matching can also be produced by index-level feature fusion [Zheng et al. 2014] between complementary descriptors. Spatial coding checks the geometric consistency between images by the offset map. For ranking problems, an effective re-ranking step typically brings about improvements. Liu et al. (2013) design a "one shot" feedback optimization scheme which allows a user to quickly refine the search results. Zheng et al. (2014) propose to leverage the profile of the score lists to adaptively assign weights to various features. In [Hirzer, et al. 2011], the top-ranked images are used as queries again and final score is the weighted sum of individual scores.

6.8 Action Recognition

Digital economy requires large repositories of digital information of various types including documents, images, videos, music and voice recordings to be compiled and stored. In particular, digital images and videos will require advanced storage and search technology commonly referred to as content-based multimedia information retrieval (CBMIR) technology. Visual concept detection (VCD) is one of the most important tasks in CBMIR [Jiang, et al, 2010; Mylonas, et al.,2009; van Gemert, et al, 2009; Snoek, et al., 2006; van de Sande, et al., 2010]. This concept aims to annotate images using a vocabulary defined by a set of concepts of interest including scenes types (mountains, snow, etc.), objects (plants, car, etc.), and certain named entities (person, place, etc.). A standard approach to VCD has been established by the research community. This involves local descriptors, vector quantization via clustering, structured scene or object representation via localised histograms of vector codes including similarity measure for the construction of kernels and classifier learning. Much effort has been devoted to develop improved solutions in each of these topics. The deployment of invariant feature detectors and descriptors [Lowe, 2004; Mikolajczyk and Schmid, 2005] has been very useful to deal with the distortion issues of occlusion, background clutter and geometric

image transformation. It has been proven that a collection of such descriptors can provide a much robust and efficient discrimination of image representation resulting in improved recognition results [Csurka et al. 2004]. This representation can further optimised using vector quantization and codebook technologies [van Gemert et al. 2010] thus making it possible to further reduce the computational complexity while still maintaining the cardinality of image representation. This technique can also benefit by using multiple quantization levels [Grauman and Darrell, 2007]. In addition, it was proven that in the case of well-structured objects and scenes, encoding weak geometric relations using spatial location histograms can lead to successful outcomes [Lazebnik et al, 2004] since high dimensional histograms can be used to efficiently compute the similarity between images. In addition, the final classification stage using Support Vector Machines (SVM) have efficiently been used especially to learn robust concept detectors generated from large-scale visual codebooks by considering kernel-based learning model [van Gemert et al. 2010; van de Sande, et al., 2010]. In addition, Bayesian [Csurka et al. 2004; Fei-Fei et al., 2006], LDA [Liu et al., 2005] and AdaBoost [Opelt, et al., 2006] have also been used in the application. For example, the authors in [Wu et al., 2009] have used a scale invariant visual language model to incorporate the spatial context into statistical language model in order to represent the objects for their categorization. Although the proposed methods are promising and have given good results individually, it was found that these methods are often difficult to integrate together to construct a robust system. This is because these different methods are optimised individually and when combined they may lead to improve the overall performances.

Automatically recognizing and localizing wide ranges of human actions has crucial importance for video understanding. This is task is challenging and currently much research is devoted towards developing a benchmark for action recognition. Up to now, video action recognition had focused primarily on the classification of pre-segmented videos, which is an artificial task. Therefore, the development of action recognition at a more practical level by introducing temporally untrimmed videos is becoming increasingly researched by the community. Among the goals background videos which share similar scenes and backgrounds as action videos, but are devoid of the specific actions are being investigated. The main goals being to develop a common benchmark for action classification and detection including the evaluation protocols used to quantify results for both classification and temporal detection.

It is recommended that action recognition should be considered as an important topic with KSA research and development strategy with a view to develop a working prototype system for inclusion in the telesurveillance vision.

6.9 Summary

In this chapter, we have discussed a few different applications of CCTV technologies. Firstly, we saw who the age estimation is tackled, in the literature, with either a regression problem or a multi-class classification problem; we also saw how the variability of aging between subjects can be a difficult issue to solve. Afterwards, we examined the question of motion tracking and a few methods available in the literature. Then, the gender identification problem was considered and it was shown how the age of the subject can be a factor that influences the classification accuracy. Gait recognition was described as a good method for person's recognition in a crowd and it was explained how a model-based or a model-free approach could be used to address some of the limitations inherent to the problem. Heterogeneous face recognition was defined as another method for person's recognition in a crowd. We particularly analysed how this technique's limitations, such as low definition, are tackled in the literature. Person's re-identification was also addressed in this chapter. It was explained how automatic recognition methods were adapted by authors to solve the issues arisen. Eventually, we saw how VCD was used for action recognition.

CHAPTER 7: CASE STUDY OF CCTV TECHNOLOGIES: PERSON TRACKING FROM VIDEO

7.1 Introduction

Human silhouettes have been widely used as the primary cues in many applications such as human pose estimation, gait recognition, and action classification. Human silhouette extraction [Chaaraoui et al. 2013; Bobick and Davis, 2001; Wang, et al. 2003; Aggarwal and Ryoo, 2011; Liu, and Sarkar, 2005] from videos is usually the primary step for these tasks. For example, many human silhouette datasets [Singh, et al.,2010; Weinland, et al. 2006] for human pose/gait estimation have been provided with manually segmented ground truth of human silhouettes. However, it can be an arduous task for such manual segmentation and it will take enormous man efforts with very expensive cost. Besides, many practical applications (such as visual surveillance) usually prefer automated human silhouette extraction so as to allow the automated analysis of vast amount of video data. Hence, automated human silhouette extraction becomes a desired component by these applications.

There are variants of approaches to detect human objects in videos. The well-known HOG pedestrian detector [Dalal, 2005] can easily detect human subjects in an image and label them in rectangles. However, it is difficult to estimate pose directly from the rectangle regions while feet and hands need to be accurately located for pose/gait estimation. In contrast, motion segmentation can easily separate the foreground human subjects from the background. Hence, human silhouettes from motion segmentation have become an important cue for pose/gait estimation [Chaaraoui et al. 2013; Bobick and Davis, 2001; Wang, et al. 2003; Aggarwal and Ryoo, 2011; Liu, and Sarkar, 2005].

However, automated segmentation of foreground objects from images or videos has been a challenging topic that attracts extensive interests in the past decade. Stauffer and Grimson (1998) proposed an efficient motion segmentation scheme using *Gaussian Mixture Models* (GMM), where the background is modeled from consecutive frames by Gaussian mixtures, and then the foreground objects can be easily segmented by

subtracting the frames with their modeled background. This method and its variations have then been widely applied for human motion analysis [Chaaraoui et al. 2013]. However, this type of methods may usually suffer from many non-ideal conditions, such as shadow, illumination variation, motion blurring, camera shaking, or similar colours between clothes and background. Fig.7.1 shows several well-known reasons that can cause the failure of background subtraction. Due to these challenges, many human silhouette datasets [Singh et al, 2010] for pose estimation or gait recognition were still heavily dependent on manual segmentation to obtain accurate human silhouettes from sample images, even when some videos have simple background scenes.

This chapter proposes an efficient silhouette extraction algorithm for this challenging task. In our approach, we take the initial motion segmentation from background subtraction as the start point, compute the Laplacian Eigen components of the image, and fit these components with the initial motion segmentation using RANSAC algorithm for accurate silhouette estimation. While the outcome of the final human silhouette segmentation is the combination of Laplacian Eigen mattes, we called our method as *Laplacian fitting*. Fig.7.2 illustrates the schematic view of our algorithm. To validate our algorithm, we tested our implementation on a number of test videos including challenging crowded scenes and non-static background with camera motions, and statistically examined how our Laplacian fitting scheme can enhance the accuracy of human silhouette extraction. The experimental outcome successfully validated that our approach can drastically enhance the accuracy of human silhouette segmentation.

This chapter is organised as follows. Section 7.2 reviews existing work on motion-based foreground segmentation while section 7.3 describes briefly the mathematical foundation of Laplacian matrix. Section 7.4 presents the Laplacian fitting using RANSAC algorithm. Section 7.5 gives the experiment results on test videos and presents some further use of human silhouettes for automated video editing. Section 7.6 concludes the whole chapter.

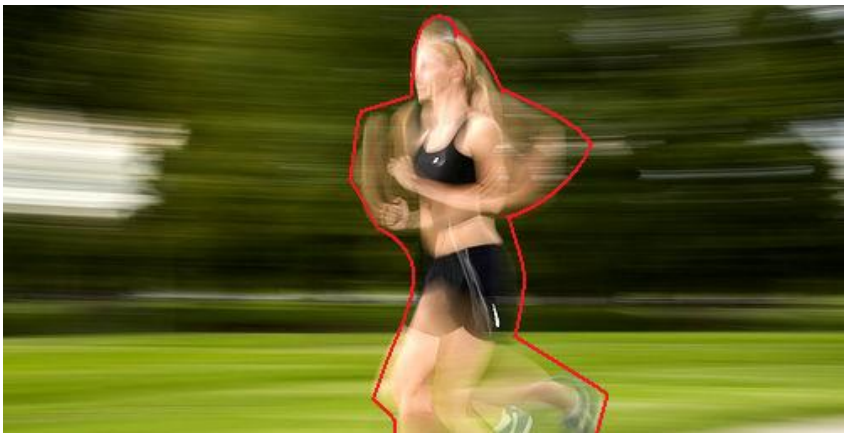
7.2 Review on Previous Work

Background subtraction is a simple method to extract human silhouettes from videos .. For example, once a background subtraction is carried out, the follow-on analysis can be easily reduced to a small region of interest (ROI) and hence can benefit from the significant reduction of both image size and inherent complexity of its content. Bobick and Davis (2001) have used human silhouettes to characterise human movements. Wang et al *(2003)* exploited human gait estimation from appearance modelling of human

silhouettes. Chaaraoui et al (2013) exploited the silhouette contours for human action estimation. aBckground subtraction can separate objects from background clutter, usually by comparing motion patterns, and can facilitate subsequent higher-level operations, such as tracking, object identification, etc. Therefore, the main step of the process is to determine an appropriate background model. A very popular approach, which was first introduced by Stauffer and Grimson (SG) (1998), is to model the distribution of colours (over time) of each pixel as a mixture of Gaussians. This method can update the background over time and hence it can cope with the variations in the background in terms of illumination variation or camera drifting. However, it usually relies only on temporal variations to model pixels discretely, and ignores spatial coherence in its background modelling. Therefore, the result can fragile to noise, light changes, shadows and other factors.

Figure Challenges in accurate human silhouette extraction: (a) Shadow 7.1may be attached to a human silhouette (b) Motion blur can easily fail the silhouette extraction and (c) The silhouette extraction is ruined by light change

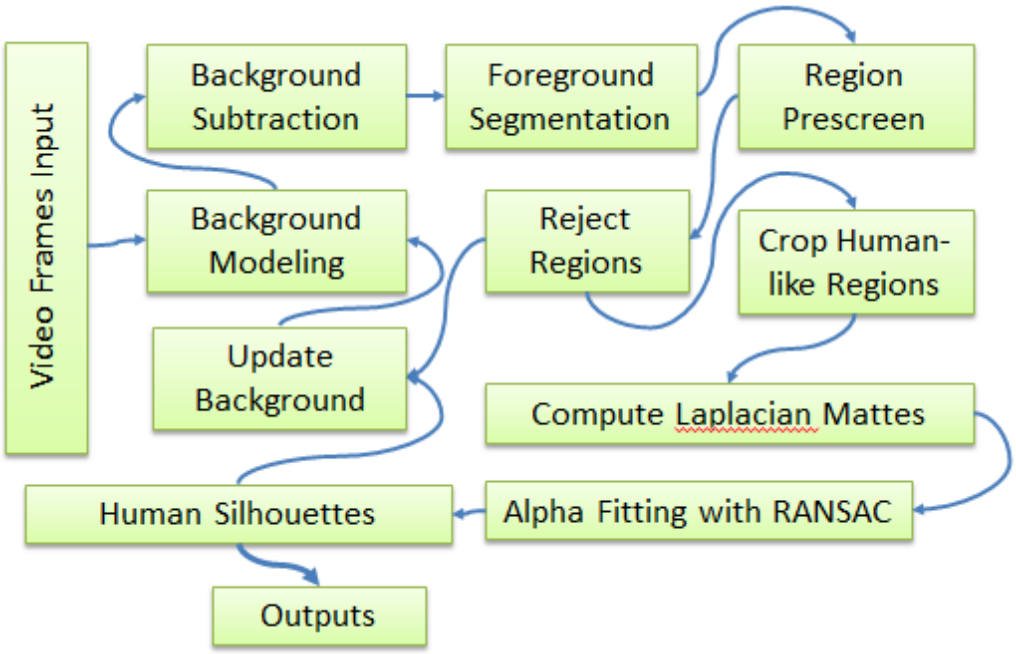
(a)



(b)

(c)

Figure 0.1 Schematic view of our Laplacian fitting algorithm.

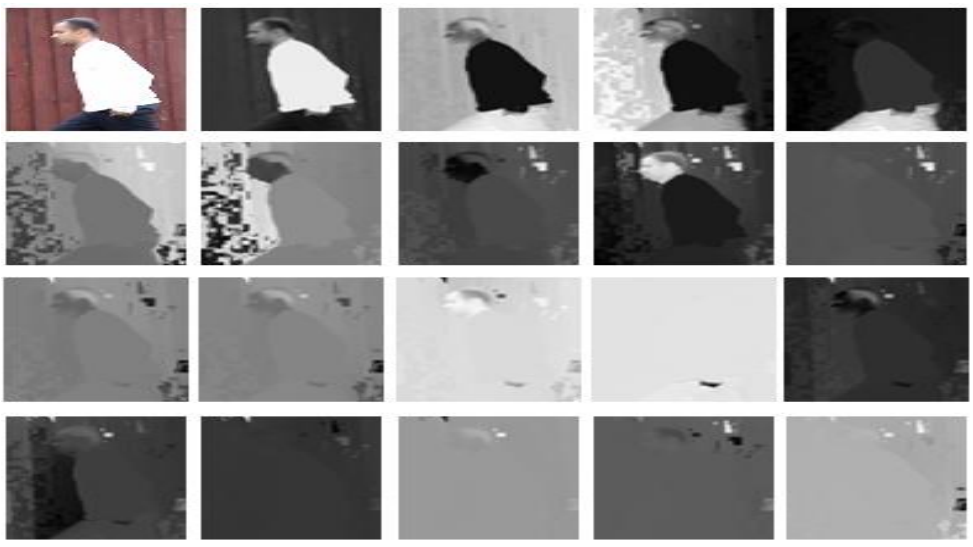


A plethora of background subtraction techniques have appeared in the literature. Heikkila and Pietikainen (2006) utilised texture information for foreground segmentation. Mittal

and Paragios (2004) introduced optical flow into background modelling. Latecki *et al* (2004) exploited spatiotemporal blocks for robust background modelling. Li modelled background in subspaces by introducing global consistency. Wixson (2000) measured salient motion for foreground object detection. Monnet *et al* (2003) proposed an incremental PCA algorithm to model dynamic background. Zhong *et al* (2003) introduced Kalman filter with texture patches into their background modelling. It is observed that these approaches have consistently enhanced the accuracy of background modelling and foreground segmentation. However, due to the inherent complexity of real videos, it is yet very challenging to extract human silhouettes accurately from videos with no human intervention. Instead, the extraction of human silhouettes in many well-known human pose datasets still relies on manual intervention [Liu, and Sarkar, 2005; Singh, et al., 2010].

This tries to address the challenge of background subtraction from another angle by incorporating spatial image analysis into the proposed algorithm to refine the initial motion segmentation generated from background subtraction. Then we propose a new scheme called Laplacian fitting for this purpose.

Figure 0.2 Laplacian Eigen mattes L_k.



7.3 Laplacian Components for Image Analysis

Consider an image but instead of paying our attention to each pixel in the image, it makes sense that we consider an image as an integration of many components that construct the image. Hence, an image can be considered as a collection of many structures in a hierarchical or parallel relation. Therefore, we introduce a method called Laplacian

matrix, which has been applied to image matting and object segmentation extensively [Zhong and Sclaroff, 2003; Levin and Lischinski, 2008].

Let us formulate the problem as a background/ foreground separation process. If one models the scene as a binary combination, we can convert the FG/BG separation into a problem of regression. By considering the background as a two-variable function $B(x,y)$ and the foreground as $F(x,y)$, the observation of the scene can be modelled as a regression problem to fit the observation with foreground and background over x-y grids,

$$I(x,y) = \alpha(x,y)F(x,y) + \{1-\alpha(x,y)\}B(x,y) \tag{7.1}$$

where $I(x,y)$ is the pixel colour at position x, $\alpha(x) \in [0, 1]$ is the alpha matte value at x.. For automated human silhouette extraction from videos, the problem becomes more challenging while no extra cues can be used in the automated process.

While the matting problem is severely under- constrained, it is usually assumed that both F and B are approximately constant over a small window around each pixel. Note that assuming that F and B ayre locally smooth does not mean that the input image I is also locally smooth, since discontinuities in alpha matte can account for the discontinuities in I. With this assumption, we have a linear function of the image I:

$$\alpha(x,y) \approx aI(x,y) + b, \forall\{x,y\} \in w$$
$$a = \frac{1}{F-B}, b = \frac{-B}{F-B} \tag{7.2}$$

where w is a local small window. This linear relation suggests finding α, a and b by minimizing the cost function,

$$J(\alpha,a,b) = \sum_k \left(\sum_{i \in w_k} (\alpha_i - a_k I_i - b_k)^2 + \varepsilon a_k^2 \right) \tag{7.3}$$

Assuming that the colour values within a local window may be expressed as a linear combination of the colour channels, the computation of mattes α becomes a minimization of the following target function,

$$\underset{\alpha}{\operatorname{argmin}} \alpha^T L \alpha, L = H^T H \tag{7.4}$$

By minimizing the above target function, we can obtain a number of Laplacian components L_k, while the separation α can be a linear combination of these Laplacian components.

Fig.7.3 illustrates the above spatial image analysis outcomes. The first image is the input, and the following are the computed Eigen components. The following problem is how to find the accurate human silhouette using these Eigen mattes.

7.4 Human Silhouette Extraction

7.4.1 Initial Motion Estimation

The proposed approach considers an initial motion estimation from a background subtraction as a cue that can be further refined. In our work, Stauffer and Grimson's method has been modified and the motion flow is incorporated to tackle the camera zooming, panning and tilting. By learning the camera model from the motion flow, the background model can then be updated accordingly. The whole procedure can be described by the following steps,

First, the input frame is extended into multiple channels to incorporate various features. Here, we convert the input RGB frames into RGB+HSV six colour channels;

- The motion estimation is carried out on consecutive frames and a coarse motion flow field is generated; the camera motion (zooming, tilting and panning) is estimated roughly from the refined motion flow field. From the camera model, the background is updated accordingly.

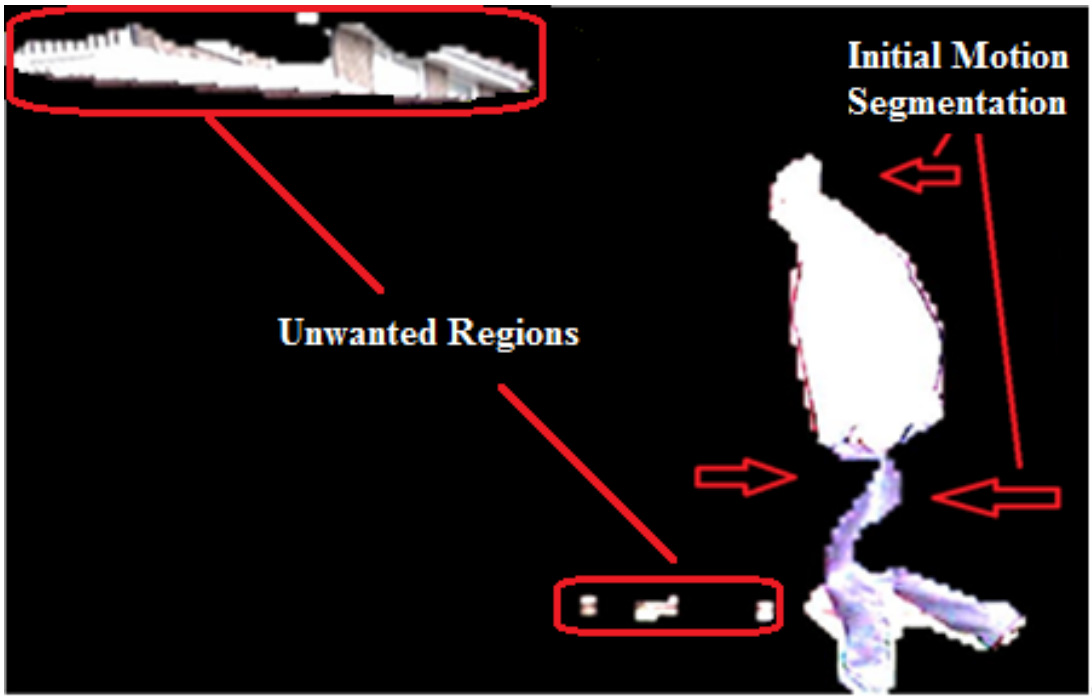
Through the background subtraction, the moving foreground region is roughly estimated resulting in a number of false-positive regions that may be wrongly detected, especially when the camera is moving or shadows are included. -Update the background in rejected regions, and keep those wanted regions for the further refinement procedure.

By performing the above procedure, one can generate the foreground regions of human subjects.

Fig.7.4-a) shows a test video, where the camera zooms into the scene and pans to follow the person walking in front of the fence. Fig.7.4-b) shows the initial motion estimation using the above method. It can be seen that a number of false positive non-human regions were wrongly detected. However, they can be easily rejected by their shape and size. Finally, only the most-likely human regions are kept for further processing. It is noticed that the remaining regions may have a considerable amount of pixels that are wrongly classified. To further enhance the results and obtain an accurate human silhouette, a Laplacian fitting scheme is proposed to refine the initial motion estimation.

Figure Figure .7.47.4 Laplacian fitting procedure: (a) a) Frames with slow camera drifting, (b) Background subtraction and region prescreening and (c) Laplacian fitting procedure. From the left: initial motion segmentation, RANSANC fitting, optimised silhouette, and final segmentation


(a)



(b)


(c)

7.5 Proposed Laplacian fitting

Using Eq.7.1, the separation of foreground and background is inherently ill-posed because it has more unknowns (F, B and α) than the constraints. It has been proposed to solve the equation by adding more information and constraints [Zhong and Sclaroff (2003); Levin et al., 2008]. The additional information is usually supplied by setting the scribbles or trimaps to label some pixels which are definitely foreground or background. To achieve this, we propose to background- based motion estimation into the equation.

After computing the eigenvectors of Laplacian mattes L and the initially estimated foreground blob map $\varphi(x,y)$, the foreground mask α can then be estimated as a linear combination of Eigen mattes with the weighting vector z,

$$\alpha = \Omega z \tag{7.5}$$

where $\Omega = \{L_1, .., L_K\}$ is the K eigenvectors of the Laplacian matrix L in Eq.(7.5) with smallest eigenvalues. To extract the alpha matte of foreground regions, it is expected that the alpha value α should be as close to the initial motion estimation φ as possible. While the alpha mask is a linear combination of the eigenvectors, we can have an optimization target function as,

$$\underset{z}{\arg\min} \left\| \Omega z - \varphi \right\|^2 \tag{7.6}$$

After the optimised z is obtained, the alpha matte can then be computed from Eq.(7.6). It is noted that the initial blob map may consist of a lot of errors with the outliers resulting in wrong foreground mattes. To avoid this problem, we introduce the iterative RANSAC procedure [19-20] to determine a solution to Eq.(7.7). In RANSAC iteration, those φ with large residues in Eq.(7.7) are considered as outliers and abandoned in the next-round iteration, and only well-fit points in the motion likelihood map are kept for the next iteration.

Taking these regions as input, we then crop them out of image and compute Laplacian Eigen mattes of these small patches, and refine the silhouette through iterative RANSANC fitting. The pseudo code of the whole procedure can be listed as follows.

With the above procedure, we can expect to extract human silhouettes from videos more accurately without human intervention. To validate our algorithm, we carried out a benchmark test on several test videos.

The whole schematic view is shown in Fig.7.2. The video frames are input, and an initial background model is estimated, and candidate foreground regions are found by background subtraction. These regions are then evaluated by a HOG classifier, and only the human-like regions are kept for human silhouette extraction.

Fig.7.4-c) shows this iteration procedure. The first image is the initially estimated motion mask φ, which can be seen not fit with the human body perfectly. The second image shows the final selection of pixels to fit in the model after RANSAC iteration. Black pixels denote the outliers in the fitting procedure, grey pixels fit with the background (α=0), and white pixels fit with the foreground (α=1). The third image shows the final optimised alpha mask and the last one shows the final segmented results. We can see that the final silhouette fits well with the human subject.

7.6 Experiments

7.6.1 Experimental Conditions

To test the proposed scheme, a set of monocular videos are used for experiment. Each frame has 352×288 pixels, and the frame rate is set to 25 frames per second. .

The experiment was carried out using three steps. Initially, we estimated the foreground human regions using the procedure described in section 7.4-A). Then, we calculated the matting Laplacian matrix and its eigenvector for each region. Finally, we applied RANSAC fitting using Laplacian Eigen mattes to refine the initial motion segmentation, and finally obtain the fitting results.

The experiment is carried out with three cases: single human objects, multiple human objects, and dynamic background with camera panning and zooming. We then statistically counted the ratios of false positive and false negative pixels in each test, and examined how much the proposed Laplacian fitting can improve in term of these figures.

7.6.2 Evaluation on Test Videos

Fig.7.5 gives the results on the test videos. The first row shows the results with simple static background, the second row shows the results on the video with multiple human objects, and the last row shows the results on a video with camera panning and zooming. The left column exhibits the original frames, the second column shows the RANSAC fitting and its selection of pixels, the fourth and fifth columns show the final fitted matte and the segmentation results. The comparison clearly shows how the proposed Laplacian

fitting scheme can refine the initial segmentation automatically where most of the initial wrongly classified pixels around were successfully corrected.

To strengthen the evaluation, we also compare our results against ground truth. Table 1 gives a statistical comparison in terms of how many pixels are correctly classified in these test videos. Here, false positive refers to the pixels that were wrongly labelled as human silhouette, and false negative refers to the pixels that were wrongly labelled as background. The ratio is computed by the number of wrongly labelled pixels divided by the total number of pixels in the ground-truth human silhouettes.

From the comparison in Table I, we can see that the proposed Laplacian fitting has successfully improved the accuracy consistently in all tests. In the first test video, the initial motion segmentation has attained a high accuracy, and the Laplacian fitting further enhanced it. In the second test video, due to the crowded scene, the initial motion segmentation has drastic false positive detection due to lights and shadows. After Laplacian fitting, the accuracy was drastically enhanced. The third one has camera panning and zooming, and consequently it has the largest false positive in its initial segmentation. Laplacian fitting successfully reduced errors in this test as well. On average, the Laplacian fitting reduced the false negative rates from 7.8% to 3.4%, and false positive rates from 14.2% to 4.7%.

Figure 0.3 Accurate human silhouette extraction from videos. 1st col.: Original frames. 2nd col.: Raw motion segmentation; 3rd col.: Outliers in black pixels identified by proposed RANSAC iteration Laplacian fitting; 4th col.: Extracted silhouettes; 5th col.: Final segmentations.

Table 0.1 Statistical results comparison

Test Videos	Initial Motion Segmentation Background Subtraction		Laplacian Fitting	
	False Negative	False Positive	False Negative	False Positive
#1	5.1%	3.5%	1.7%	1.5%
#2	5.2%	35.5%	5.1%	11.2%
#3	13.2%	6.5%	3.3%	2.3%
#4	7.6%	11.3%	3.5%	3.7%
Average	7.8%	14.2%	3.4%	4.7%

Figure 7.6 using Laplacian fitting for automated video editing (a) Background replacing and (b) Clone the human target in the scene

(a)

(b)

7.7 Summary

This chapter has presented a novel automatic human silhouette extraction using Laplacian fitting. In the proposed scheme, motion cues are roughly estimated, and then refined by the proposed RANSAC fitting scheme. The experiment on test videos successfully validated the use of Laplacian fitting can greatly enhance the accuracy in automated human silhouette extraction. With this scheme, we enabled the robust human silhouette extraction with little human intervention and hence it saves a lot of man efforts in video processing. Further experiment demonstrates its potential use in automated video editing tasks.

It is worth to mention that the proposed Laplacian fitting can be considered a generalised method that can fit with or separate any types of correlated data of two or more classes. Hence, potentially it has more applications than a specific problem besides the automated human silhouette extraction in this chapter. We will investigate its further use in our future work.

8 CONCLUSION AND FURTHER WORK

8.1 Introduction

As has been stated throughout this study, security is now becoming an extremely delicate issue to manage; decision-makers have now come to a conclusion that the use of CCTV surveillance systems can significantly help detect and reduce crimes of all kinds. Naturally, the process of implementation and installation of CCTV has been a sensitive issue across the world, leading to significant political, economic, social and legal implications. Saudi Arabia, like most countries of the world, has been engaged in deployment of CCTV surveillance systems for many years now. However, the Saudi case, unlike other cases, is not as straightforward as anticipated. The Saudi laws are based on the Sharia Law which clearly states that no picture/video of any Muslim women or men should be taken without their full consent. In the light of this law, the case for an extensive network of CCTV surveillance has proven to be extremely challenging for the decision-makers in the country.

In order to find answers to this rather delicate puzzle, the research has embarked on a number of approaches and methods. The rest of this chapter attempts to highlight, discuss and encapsulate the main issues raised throughout the thesis. Section 8.2 reminds the readers the aims, objectives and questions, which have driven this study. Section 8.3 highlights a summary of the main foundations of the literature on CCTV deployment strategies. Part four embarks upon a number of issues, approaches and findings arising from the study by offering a platform for discussion, primarily based on the questions of the research. Part five offers a number of recommendations arising from the study; whilst part six presents the overall limitations of the study and hence offers some directions for future research. The chapter ends with some concluding remarks.

8.2 Aims, Objectives of the Thesis: A Review

As discussed in the Introduction chapter, the aim of this study has been to examine how CCTV surveillance systems and technologies can be effectively used in Saudi Arabian businesses complying with the country's cultural and religious values and regulations. In so doing, the research also has aimed to identify the factors that can take part in the

effective usage of CCTV systems in Saudi Arabia. Work in this thesis is driven by the researcher's goal to find appropriate answers to the following questions:

VIII. How the KSA cultural and traditional values affect the deployment of CCTV systems within the kingdom?

IX. How to develop a framework for effective deployment of CCTV systems in KSA?

X. How persons can be detected in CCTV videos?

This study has adopted a method of investigation based on a mixed approach resting on both qualitative and quantitative methods. In the absence of any published data and previous studies, the research took the initiative of conducting a mixed survey of three pre-selected organisations (two large hospitals and a jewellery shop) by developing and applying three different questionnaires to two broad groups of participants: customers/patients, and staff. In particular, a special questionnaire was designed for the staff working in the control rooms of these organisations with the aim of collecting as much information as possible about the technology used and the quality of supervision carried out in running the control rooms and monitoring procedures.

8.3 Discussion

This section briefly discusses how the three key research questions were addressed and how this work compares with some of the key existing works on the subject of CCTV systems.

8.3.1 Research questions coverage

Question 1: To what extent do the KSA cultural and traditional values affect the deployment of CCTV systems within the Kingdom?

The case studies examined here represent two public places (hospitals) and one private business (Alfardan jewellery) which have recently commenced deployment of CCTV cameras in a number of locations. As discussed in chapter six, there has been no clear directive or protocol from the government vis-a-vis standards, rules and regulations in all aspects of decision-making process, with the potential ethical issues arising from use and application of CCTV.

The examination of the literature surrounding the potential of cultural values in Saudi Arabia has offered some insights into the power of Sharia Law, but not the extent of its influence on CCTV deployment. In order to find the appropriate answer(s) to the above

question regarding the extent of cultural/religious effects on CCTV deployment a careful examination of the findings, derived from the Analysis chapter, can prove helpful. To make the discussion on the issue of the extent of influence of cultural/religious values, the examination of the findings relating to perceptions of customers/patients is relevant here. The overall perceptions about the potential safety of CCTV turned out to be highly satisfactory where most participants were of the view that, other things equal, the presence of CCTV surveillance can make them feel safe and secure. However, a large majority of participants were concerned about two issues: privacy invasion, and controllers' misuse and abuse of the video material.

One major finding in relation to acceptance of CCTV surveillance systems was found to be the level of educational attainment and/or knowledge of CCTV and general computing. The study showed that the higher the participants level of education or the knowledge of CCTV the lower would be the strength of cultural/religious values and hence the higher the chance of acceptance of the CCTV deployment. More specifically, it was found that a 1% increase in a combination of knowledge of CCTV and general higher education would lead to nearly 0.5% drop in opposition to CCTV surveillance systems.

On the whole, the findings suggested that a large proportion of respondents do appreciate the benefits of CCTV, such as safety and reliability and its potential for crime reduction. Similar findings for the UK and other European countries have been reported in previous studies as highlighted in the Literature chapter. Nevertheless, the concern about CCTV seems to outweigh the benefits. The findings showed that people are very sensitive to both privacy invasion and controllers' abuse of CCTV footage.

Question 2: How should one develop a framework for effective deployment of CCTV systems in KSA?

The findings from the Analysis chapter along with the comments made by a number of interviewees, tend to suggest that the main reason behind opposition to deployment of CCTV in public places lies in the very fact that perceptions have been based on the negative impact that such systems can bring. On the positive side, it was noticed that there appeared to be a very strong correlation between knowledge of CCTV and/or educational attainment and fear of CCTV. It was found that the higher the knowledge f CCTV or education the lower would be the fear of deployment of CCTV. However, as the findings revealed, a genuine and vexing fear, declared by a significant number of participants

related to lack of trust to staff working in control rooms. The questionnaire addressed to the controllers in these three organisations revealed that there had been limited resources poor supervision and monitoring across the board. On the question of how to tackle this problem and change people's perception about CCTV surveillance systems, several points are worth noting here. First and foremost, in the light of the findings, a comprehensive programme of educating people about the real usefulness of CCTV should be introduced nationwide. Particularly, such programmes should be conducted in major cities where there have been more CCTV cameras deployed, offered free of charge to all citizens. This programme should consider the real facts about CCTV systems in helping law enforcers to tackle crimes and provide a safe and secure environment for the citizens. It is therefore clear that provision of accurate and straightforward knowledge about CCTV technology and its potential benefits can help reduce concern about CCTV significantly. Suffice to say that such strategy should be promoted and financed by the Saudi government, helping to weaken the current state of concern about CCTV surveillance systems.

Secondly, in changing people's perceptions about the potential misuse and abuse of material by controllers in public places, government agents must approach the issues from several corners. As discussed in Chapter six, a number of compulsory nationwide courses should be offered to address the relevant information and expertise from managerial to installation of CCTV system. In particular, educating the staff in control rooms can prove to help improve the perception that the public hold against them. Furthermore, the courses in supervision of CCTV control rooms can provide the ethical issues required by the staff to improve their current status. In addition, training on short term basis have already commenced in most public and private institutions in the country aiming to tackle the technical and managerial aspects of CCTV surveillance system.

Question 3: How people can be detected from CCTV video?

The part was concerned with an investigation into an application to enable the detection of people from video data. Various application areas including face recognition, action recognition were investigated. It was found that a person detection and extraction using an automatic silhouette extraction was chosen. The technique proposed uses the concept of background/foreground subtraction which was modelled by taking into account the environmental distortions such as noise, blur, etc.

8.3.2 Comparison with existing works

Existing and related works which can be compared to the work reported in this thesis falls into mainly two groups: Japanese and European. On the one hand, the Japanese studies (e.g., Yokotea et al., 2010; Prashyanusorn et al., 2011; Adams, et al., 2012) are focused more on technological aspects of CCTV Systems, whereas on the other hand, the European studies (e.g., …) have focused more on addressing regulations and privacy issues besides technological aspects. Conversely, the work reported in this dissertation takes a more holistic view of the matter in the context of KSA, which brings aspects never addressed before (e.g., cultural and religious issues and objections to widespread deployment of CCTV Systems on various grounds). Moreover, this study integrates all the issues and aspects around CCTV systems into a framework, which will make adoption and deployment of CCTV Systems in KSA more effective, feasible and acceptable.

8.4 Contributions

A large number of research works has recently emerged in the area of CCTV system deployment in different parts of the Middle East. However, to date, no genuine academic output has come out to consider all aspects of deployment of CCTV in Saudi Arabia. In particular, very little work has considered the cultural and religious aspects of Saudi Arabia and their impacts on the effective deployment of CCTV systems in the country.

The findings from this research will enable academicians and decision makers to identify and evaluate the extent of effectiveness of social, political, economic, cultural, and technological factors against security enhancement in shaping the resistance to deployment of the CCTV system. The research has conducted a detailed analysis of the use of management and how to adopt technology in control rooms for fully exploiting benefits of CCTV deployment in the KSA.

For an advanced CCTV technology, the researcher has recommended that action recognition should be considered as an important topic with KSA research and development strategy with a view to develop a working prototype system for inclusion in the tele-surveillance vision. Furthermore, the research has addressed the limitation of the above background-based human silhouette extraction, and proposed an accurate silhouette extraction scheme for this challenging task. In this work, motion segmentation from background subtraction has been adopted allowing us to compute the Laplacian

Eigen components of the image, and fit these components with the initial motion segmentation to effectively estimate the silhouette from video data.

8.5 Recommendations for Saudi Arabia

Based on the thorough examination of the literature and analysis of the survey of customers/patients and staff of three organisations in Saudi Arabia, the study has come up with the following recommendations:

(i) In the light of the negative perceptions of people about the privacy invasion and lack of trust to CCTV controllers, the study recommends that a comprehensive nationwide programme of education to be offered free of charge, by the government in cooperation with the private sector, aiming to provide information to the public about the real benefits of surveillance systems.

(ii) As the study has found serious problems with quality management of control rooms, it is recommended that education, official training and certification, and general awareness program for controllers must include ethical and managerial responsibilities and accountabilities. Furthermore, by introducing a number of by-laws, the project or risk manager must be made responsible for maintaining the frequency of supervision and quality of service in order to reduce any likelihood of abuse by controllers.

(iii) In pursuing the above recommendations, the government, with the support of private sector, must make every effort to come up with a comprehensive and workable protocol, leading to development of a centre of excellence. The current ad hoc and unclear set of non-binding rules and regulations on surveillance does no one any service. The study, therefore, recommends that the centre should encourage the experts and businesses to participate in developing and shaping a comprehensive nationwide document containing policies, strategies and evaluative approaches on CCTV and similar surveillance systems deployment.

8.6 Limitations and Future Research Direction

Despite efforts made to avoid shortcomings, there are a number of limitations attached to this study, as follows:

XI. (i) Although the literature used in the study tends to consider a large number of countries and their experiences vis-a-vis deployment of CCTV surveillance systems, this research is solely based on Saudi environment. The findings, therefore, cannot be generalised to other countries at similar stages of social,

economic and political development. For the purpose of international comparison of findings, future research may be encouraged to examine a broader survey of countries, such as those in the Gulf Cooperation Council, where they tend to enjoy similar stages of social development and technology

XII. (ii) The findings and analysis in this study are primarily based on only three organisations with a limited number of participants; hence may not necessarily represent the general views of the population at large. The policy implications and recommendations offered by the research, therefore, must be considered with care and caution. Future research, therefore, can undertake a larger number of cases with much larger sample of participants to achieve a more robust statistical results.

XIII. (iii) Finally, the methodology employed here is based on a triangular approach consisting of questionnaires and interviews. In addition to surveys, the future research may be in a position to have access to some published information and data; hence enjoying a much greater success at arriving a more comprehensive set of findings and recommendations.

8.7 Conclusion

The main conclusions that can be drawn from the work reported in this dissertation follows. Firstly, as discussed in lengths in the previous chapters, although a large majority of participants did appreciate the benefits of CCTV systems in reducing crimes and enhancing safety, concerns were expressed about two issues: privacy invasion, and controllers' abuse of recorded material. However, further analysis of data, using both linear and logistic regression models, showed that by introducing the variables such as knowledge of CCTV, and general educational attainment, one can distinguish between the participants. It was demonstrated that the fear about privacy invasion and abuse by controllers could be significantly diminished once people become aware of the real usefulness of CCTV, either through general improvement in education or enhanced knowledge of CCTV technology.

Secondly, in the light of participants' lack of faith in controllers, the study made a number of recommendations, which could help policy makers to address the issues in a more strategic manner. In short, in order to change the negative perceptions of the people, largely fuelled by cultural and religious factors, about the deployment of CCTV, it was suggested that the government must embark on a nationwide programme of education aimed at enhancing the potential benefits of surveillance systems.

Thirdly, it was recommended that in addition to educational programmes, the Saudi government must move towards establishing a centre of excellence in charge of designing and building of a concrete and workable set of documents relating to CCTV deployment policies. In the light of recent security alerts in the Kingdom, the study concludes by stating that people are now becoming very sensitive to safety and security issues, particularly those relating to the prevalence of terrorism. In the recent years, the logical arguments made by the government in relation to issues of safety and security have proven successful as the public have realised that the security risk are much greater than other risks associated with CCTV management.

Finally, a thorough examination and evaluation of the relevant technology revealed that alongside improvement in training and education, the appreciation and deployment of appropriate technology is highly crucial in achieving the Kingdom's objectives. In particular, in enhancing security measures, a careful examination of technology showed that a Laplacian fitting can greatly enhance the accuracy of automated human silhouette extraction of any types of correlated data of two or more classes. Hence, potentially it has more applications than a specific problem besides the automated human silhouette extraction.

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APPENDICES

A)THE SURVEY QUESTIONS (CCTV)

1The Survey Questions (CCTV) – Staff working in Hospital & Alferdaan

1) What is your gender?

Male	Female

2) What is your qualification?

No Qualification	
Intermediate	
Intermediate	
Graduate	
Postgraduate	

3) What is your current Job?

Management	
Clerical	
Admin	

4) Do you think CCTV Systems are good option at work environment?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

5) Have you worked under CCTV Surveillance system?

1-2 Years	3-5 Years	6-8 Years	+8 Years

6) Do you believe CCTV system improved worker performance?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

7) In your experience do you think CCTV is a good crime prevention method?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

8) Is crime/theft reduced or just moved to areas without CCTV Surveillance?

Yes	No

9) Does CCTV affect the way you behave in job?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

10) Overall how useful is CCTV in workplace?

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Especially in Office timing					
Dramatically improve work					
All staff work properly					
Employee feel safe on job					

11) Do you think clearly visible presence of CCTV in office enables incident to be more quickly and effectively dealt with?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

B) The Survey Questions (CCTV) – CCTV Controllers & Management Team

12) What is your gender?

Male	Female

13) What is your qualification?

No Qualification	
Intermediate	
Intermediate	
Graduate	
Postgraduate	

14) What is your current Job?

Management	
Clerical	
Admin	

15) How many cameras do you currently have at your work area?

4	8	16	16+

16) How many of the current cameras are IP and how many are analog?

Textual Answer:

_____

_____

_____

17) What brand and make IP cameras do you have and what brand and make PTZ Cameras do you have?

Textual Answer:

_____

_____

_____

18) How many of the cameras are fixed and how many are PTZ?

Textual Answer:

_____

_____

_____

19) How many control points do you have to monitor the system?

1	2	3+

20) How many monitors do you have at each control point?

1	2	3+

21) How many images per second do you record from each camera?

50	100	150	150+

22) How many day(s) of retention do you store the cameras?

1	2	3+

23) What is the current infrastructure for the cameras? Coax, fiber, twisted pair, cat 5, cat 6, wireless?

Textual Answer:

_____

_____

_____

24) Will you be actively monitoring the system and recorded video?

Completely	A lot	Little	Don’t know

25) If you are actively monitoring the system how many people will be viewing and how many cameras will they be looking at in any one given time?

Textual Answer:

_____

_____

_____

C) The Survey Questions (CCTV) – Customer at Alferdaan Jewellery

27) What is your gender?

Male	Female

28) What do you know about CCTV Systems?

No	A Little	A Lot	Completely

29) Does the use of CCTV concern you?

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
When I am at home					
When I am at work					
When I am at leisure					

30) How reliable do you think CCTV Surveillance system is?

Not Reliable	A Little	A Lot	Completely

31) Do you think CCTV System around you can help in reducing the crime?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

32) Do you think CCTV System as invasion of Privacy?

No Opinion	No	A Little	A Lot	Completely

33) Does CCTV System make you feel safe and protected against intruders?

Yes	No

34) Where do you think you could rely on CCTV the most?

Completely	A lot	Little	Don’t know

35) What is your perception of the overall level of crime in your area?

High	Above Average	Average	Below Average	Don’t Know

36) Are you aware of any CCTV Camera in your city?

Completely	A lot	Little	Don’t know

37) Do you think controllers of CCTV might abuse the system?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

38) Do you think evidence from CCTV might be misleading?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

D) The Survey Questions (CCTV) – Patient at Hospital

39) What is your gender?

Male	Female

40) What do you know about CCTV Systems?

No	A Little	A Lot	Completely

41) Does the use of CCTV concern you in hospital?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

42) How reliable do you think CCTV Surveillance system is?

Not Reliable	A Little	A Lot	Completely

43) Do you think CCTV System as invasion of Privacy?

No	A Little	A Lot	Completely

44) Does CCTV System make you feel safe and protected in Hospital?

No	A Little	A Lot	Completely

45) Where do you think you could rely on CCTV the most?

No	A Little	A Lot	Completely

46) Do you think controllers of CCTV might abuse the system?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

47) What do you think CCTV System should work in Hospitals?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

48) Do you feel safe when CCTV System fully operational in Hospital?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

49) Do you think CCTV System should be working in meeting rooms?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

50) Do you think evidence from CCTV might be misleading?

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree

51) Which time of the day do you feel most safe in Hospital, monitored with CCTV?

12am -6pm [ ]

6am -10am [ ]

10am -12pm [ ]

12pm -2pm [ ]

2pm -6pm [ ]

52) Do you recommend anything regarding CCTV System for Hospital?

Textual Answer:

_____

_____

_____