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# **Employing Information and Communications Technologies in Homes and Cities for the Health and Well-Being of Older People**

**ICT4HOP'16**

15 – 17 August 2016

Sichuan University, Chengdu, China

## **WORKSHOP PROCEEDINGS**

Edited by:

Prof. Xiaohai He, Sichuan University

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SICHUAN UNIVERSITY



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## Welcome to ICT4HOP'16

**15-17 August 2016, Chengdu, China**

We are delighted to welcome you to the 1st International Workshop on Employing Information and Communications Technologies in Homes and Cities for the Health and Well-Being of Older People (ICT4HOP '16) in Chengdu, China.

The workshop is jointly organised by Sichuan University and University of Bradford, with the generous support of the National Natural Science Foundation of China (NSFC) and the British Council Researcher Links scheme offered within the Newton Fund. The workshop is hosted by the College of Electronics and Information Engineering, Sichuan University.

Cities in China, the UK and around the world face an ever increasing challenge in ensuring the health and well-being of their growing ageing populations. The abstracts contained within the Workshop Proceedings describe some of the innovative, multi-disciplinary approaches that are currently being investigated to address this challenge through the use of information and communications technologies.

Scheduled over 3-days, ICT4HOP'16 brings together in the region of 40 early career researchers to present and discuss their work. The programme provides a platform for three keynote speakers, three technical sessions and a poster session, together with an abundance of social and cultural opportunities to network and establish new research links.

We anticipate a vibrant and enriching workshop, and look forward to what promises to be an exciting, ground-breaking and informative experience.



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## The Newton Fund

The Newton Fund is a £735 million fund (over 7 year lifetime) which, through science and innovation partnerships, aims to promote the economic development and welfare of poor people in developing countries. The Fund is overseen by the Department for Business Innovation and Skills (BIS) and delivered through 15 delivery partners in collaboration with 15 partnering countries. For more information visit: [www.newtonfund.ac.uk](http://www.newtonfund.ac.uk)

## Acknowledgements

Putting together an international workshop of this type requires a significant amount of effort from a number of individuals. We are especially grateful: of the tremendous support provided by Dr Yanmei Yu and Dr Linbo Qing of Sichuan University, for their work in coordinating the organisation at Chengdu; to Ms Xiaolei Wang of University of Bradford for her assistance with travel arrangements and visa applications; to the University of Bradford Faculty of Engineering and Informatics' procurement team, led by Mr Matt Overton, for their ability to efficiently arrange the flight tickets and associated expenses of the UK delegates; to the College of Electronics and Information Engineering of Sichuan University for its support of the workshop.

We are thankful of the generous support of the NSFC and the British Council Researcher Links Newton Fund for providing us with this exciting opportunity to provide a platform for further research and development initiatives between our respective nations.

Finally, our Workshop would not be possible without the outstanding contributions of the early career researchers from China and the UK, which has ensured that we have a stimulating three days of activities to look forward to.

## Sponsors



National Natural Science Foundation of China



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## KEYNOTE SPEECHES

## **Harnessing the Value and Potential of Technology for an Older Population**

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### **Abstract**

My contribution will be sharing knowledge and expertise of ageing and lifestyle (including technology use) in the extended lifespan with workshop participants. The learning outcomes will include appreciation of both the contribution and needs of older people including those with specific health needs; understanding of current state of the art in technological applications for older people and appreciation of the potential role of technology in future health and social care services and in community living.

We will firstly discuss the contribution that older people make to society as well as the issues that can arise from our greater longevity. I will assist participants to explore their experiences and perceptions of ageing, which will include how ageing is portrayed in society.

Following this we will consider how policy is seeking to address the needs of an ageing population globally. At this point we will share some of the myths and realities of technology use by an ageing population.

This will lead into the possibilities that technology might provide for health and social care for older people. We will also consider how technology might enable continued independence and be used for leisure and social connectivity (in common with the rest of society). We will also explore how good design can promote use of technology and alternatively how poor design can dissuade engagement and use.

Each of the above areas; health and social care, continuing independence and leisure and social connectivity will be discussed in depth including the spread of existing research evidence and the gaps in knowledge.

Participants will be encouraged to think of existing everyday technology; how it is used now and how it might be re-engineered to meet the needs of an older population. They will be facilitated to think into the future; what might be in common use in 10 years; how might a new disruptive technology create change: what about ubiquitous computing/ the internet of things; what changes to health and social care services are likely and what part will technology play.

If there is interest, time can be spent thinking about the specific needs of people with dementia and how well designed technology can assist people to remain independent for longer.

## Smart Cities with Advanced Technologies and Quality Services

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### Abstract

Since last century, the economic development has promoted a rapid growth of the global urban population. This trend is still continuing now. One hundred years ago, the urban population was accounted for 14% of the global population, then currently is accounted for about 50%, and is estimated to be about 70% by 2050. Many cities nowadays are facing challenges from various problems such as economic restructuring, waste management, ageing populations, traffic congestion, environment issues, crime rate, etc. It is desirable to apply the advanced technologies as well as the modern management methodologies to effectively deal with these problems and bring better quality of life for people of all ages living in urban areas.

In last several years, the smart city concept has been spreading all over the world. The goal of a smart city is to improve the quality of life by using technology to increase the efficiency of services and meet residents' needs. The local government, companies, non-profit organizations and the citizens themselves embrace the concept of the smart city, employing more technologies, especially the information and communication technologies, creating better life conditions and safeguarding the environment. Over 600 cities around the world have taken their initiatives to develop toward the smart cities. But each city may put a different emphasis in its smart city development.

What is a smart city all about? How can a smart city bring the benefits to its citizens? In this talk, we will discuss what generally concerned with a smart city and address important issues in a smart city. While the definition of a smart city appears to be very diverse, we view a smart city as an urban area that integrates human wisdom and modern technologies to improve the quality of life for its citizens, increase the efficiency of city operations, and promote the local economy. We identify ten categories in the context of smart city as: smart environment, smart public safety, smart city operations, smart education, smart transportation, smart communications, smart community, smart medical, smart commerce, and smart energy. Based on that, we will explore what is expected in each of the above categories and present what can be done by employing modern technologies such as Internet of Things, Information and Communication Technology. With these technologies it allows the city management to interact directly with the community and to monitor what is happening in the city, so that the efficiency of services can be improved.

In the end of the talk, we will lead a discussion on the opportunities and challenges we may have when building a smart city.

**Keywords:** Smart City, Information and Communication, Quality of Life, Internet of Things.

## Big Data for Precision Medicine and Personalised Healthcare of Elderly

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### Abstract

The ageing population in China is rapidly growing. In 2014, the population of over 60s was 212million, rising to 243million by 2020. Over 65s are forecast to grow to 167million by 2020 in China accounting for 11.5% of the population. It is expected to increase by around 10 million every year, and is set to peak around 2030, and account for almost one third of the Chinese population by 2050. WHO stated that on January 2015 chronic non-communicable diseases (NCDs), such as lung cancer, stroke, heart disease and diabetes, accounted for 8.6 million deaths in China in 2012. These chronic disease account for 85% of all deaths in China and require some 70% of medical resources.

In the era of big data, the real world evidence gathered from real-time big data and advanced machine learning and data analytics techniques provide opportunities to gain actionable insight from the large amount of data. This is becoming the strong driving force for the innovation of healthcare and healthcare system. Big data is particularly expected to drive the improvement of patient safety and outcomes of treatments that ultimately improve the quality of life; and on the other hand, to reduce costs of healthcare and increase the operational efficiency.

This talk will include two parts: (1) it firstly introduces the new discipline of data science including its framework, core technologies, its opportunities and challenges in medicine and healthcare, and its potential to unlock the scientific value of healthcare data; (2) it then discusses the role of big data in the next generation medicine and healthcare – the precision medicine and the personalized healthcare. On the subject of precision medicine, the current development of using big data including genome data and clinic data in precision medicine will be introduced. This follows a presentation of new scientific findings of integrated analytics of genome and healthcare big data, including some research findings of the speaker's group and others. This talk will then present a new framework of data-driven personalized healthcare and the associated key technologies and systems. In the end the talk a discussion on the challenges of big data analytics to gain insight from the integration of big data will be presented.

**Keywords:** Big Data, Precision Medicine, Personalized Healthcare, Integrated Healthcare.

## MRI Techniques in Alzheimer's Disease

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### Abstract

Alzheimer's disease (AD) is one of the most common disease in elderly population. It is a chronic neurodegenerative disease that usually starts slowly and gets worse over time. The most common early symptom is difficulty in remembering recent events. Gradually, bodily functions are lost, ultimately leading to death. By 2016, the number of global AD patients increased to 48 million, and Chinese patients accounting for 25% of this population. So far, no treatments stop or reverse its progression. Affected people increasingly rely on others for assistance, often placing a burden on the caregiver; the pressures can include social, psychological, physical, and economic elements. Even worse, the non-invasive diagnosis of AD is difficult. The only truly diagnosis can be only made autopsy after death of the patients. In practice, diagnosis of AD is based on clinical criteria. In addition, findings from magnetic resonance imaging (MRI) techniques could further increase the diagnostic accuracy of AD.

One of the promising extensions of the findings in MRI is the use in the analysis of large clinical data, in which a large amount of anatomical MRIs of elderly population, collected through multiple institutes, could be used to evaluate diagnostic probability of AD or to evaluate future risk for developing dementia, for a single individual basis. A range of studies have demonstrated that the morphometric features extracted from the structural MRI, along with machine learning techniques, could be used to classify a single subject as a member of a particular clinical category. One group of these studies consider voxel-based tissue probability maps directly as features in the classification. Another group focuses on the regional characteristic such as volume, shape, thickness within one single anatomical structure, or the multivariate description over the whole-brain parcels obtained using automated segmentation tools. The third group first characterizes the shape of a ROI as a series of parameters, such as spherical harmonics or log-Jacobian determinant from tensor-based morphometry, and then utilizes the parameters as features. Apart from morphometric measurements, other image modalities of MRI have also been developed as biomarkers for AD Identification. Diffusion tensor imaging (DTI), in particular, is a promising measurement as it was demonstrated to be consistent with pathological axonal structures, termed as white matter integrity, in AD patients.

In this talk, we will discuss the aforementioned MRI imaging markers, and answer:

- (1) How to extract features from MRI images?
- (2) Can these feature really recognize AD?
- (3) What is the level of precision of the features? Can we improve the precision?

**Keywords:** Alzheimer's Disease, MRI, DTI, Recognition.



# CONTRIBUTIONS FROM THE UK

Comprising 17 abstracts from 11 UK Institutions

## Improving Aging People Healthcare by Wearable Vital Sign Monitoring Devices

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### Abstract

The number of people of pensionable age is projected to increase by 31% from 12.3 million in mid-2012 to 16.1 million by mid-2037; the population aged 80 and over is projected to grow from 3.0 million to 6.2 million, more than doubling in the next 23 years. At the same time, AgeUK noted that “17% of older people have less than weekly contact with family, friends and neighbours”. In addition, there are 15.4 million people in the UK who suffer from long term conditions, such as Neurological disease, age and chronic disease related osteoporosis, strokes, fainting etc. all increase the patients' risk of falls. These figures show the increasing risk of elderly people or population suffering long term conditions not being monitored from minor incidents or falls in the home or from illness or unforeseen situations which would go undetected if no contact is made for a long period of time.

These urge a great demand for producing home care assistive residential installed monitoring equipment, mobile devices or even wearable sensors to ascertain their wellbeing by interactive and remote monitoring. Development of such technology not only becomes an economically viable means of supporting a patient remotely but presents an opportunity to identify deteriorating trends in a patients' condition by developing predictive, early intervention and remedial actions.

This kind of elderly monitoring system often need to be non-invasive with the minimum level of disturbance to their life styles. The readings will be either automatically taken or be simple enough for non-professional users to carry out. The vital sign monitor and wearable medical bracelet developed in our research group collaborated with iMonSys will enable a full customisable solution for elderly people care at home capable to provide wide ranges of readings including ECG, PPG, heart rate, SPO2 and blood pressure.

The readings related to individuals are often needed to be gathered and uploaded to professional healthcare centre for further processing and analysis in order to identify the issues faced by the individuals. As a result, a great amount of the elderly population for continuous monitoring, acquiring and analysing data from the distributed devices become a challenge to data communication, storing and processing. The pre-processing in the devices as well as the connected tablets have been envisaged as an efficient front end sensor data processing approach where only relevant and meaningful information will be sent out for further processing to relieve the burden of the information storage and processing challenges.

**Keywords:** Wearable Healthcare Devices, Vita Sign Monitoring, Data Mining.

## Presenting a Grounded Theory of Mobile Technology Use

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### Abstract

#### *Background:*

A systematic review and meta-synthesis (Fulford et al. In Press) identified that no research had explored how people with mood disorders used mobile information and communication technology (mICT) in their everyday lives and more specifically, how they might use mICTs to look after themselves. This oversight has led to technology redundancy and high attrition rates. Further research was therefore required to understand the meaning this type of technology held for people with mood disorders.

#### *Aims/Objectives:*

The study aimed to explore the views and experiences of using mICTs by people with mood disorders, and their mental health care professionals. A qualitative study using in-depth, semi-structured interviews with twenty-six people with mood disorder in secondary and specialist mental health services and 10 mental health care professionals.

#### *Method:*

Participants' data sets were analysed using Constructivist Grounded Theory. Grounded theory involves the gradual identification and integration of categories of meaning from the data, and the identification of relationships between them.

#### *Results:*

A grounded theory of how mobile technology is used in daily life, and also, more specifically, how it might be used to manage recovery from mood disorder. The core category which emerged from the data forming theory was 'Centrality through Interconnectivity' and this with its sub-categories will be discussed.

#### *Discussion/Conclusion*

The research study has begun to fill the gap in our understanding in regards to the meaning this type of technology holds for people with mood disorder and such research might provide valuable information on how technology is subjectively and collectively perceived. As the mark of a good grounded theory is its adaptability, it holds the potential to help understand how mobile technology is used by people with other forms of mental health loss, such as dementia, and its role in the management of long-term conditions. The workshop will hopefully help explore and adapt the grounded theory to support the care of people with dementia, inform technological design and support clinical practice.

**Keywords:** Grounded Theory, Qualitative Study, Mood Disorder, Mobile Technology, Metasynthesis.

## The Role of Defeat and Entrapment in Mental Health: Current Evidence and Future Adaptions for Clinical Settings

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### Abstract

Defeat (conceptualised as a failed social struggle) and entrapment (conceptualised as a perceived inability to escape from aversive situations) form a single construct that reliably predicts psychopathological outcomes in clinical and community settings. Participants (N=172) were recruited from economically deprived areas in North England. Over half of participants (58%) met clinical cut-offs for depression and anxiety. Participants completed measures of defeat, entrapment, depression and anxiety at two time-points twelve months apart. Regression analyses demonstrated that changes in depression and anxiety between Time 1 and Time 2 were predicted from baseline levels of defeat and entrapment; however, changes in defeat and entrapment were also predicted from baseline depression and anxiety. In a second longitudinal study, changes in caregiver burden and depression between Time 1 and Time 2 were predicted from baseline levels of combined defeat and entrapment, for care staff who provided care for people living with dementia and other conditions. As a result of these findings, a scale has been developed to measure defeat and entrapment in a concise manner, to improve the measurement of defeat and entrapment within clinical settings. Research should now consider how measurement of defeat and entrapment can be adapted to provide a reliable measure of these constructs amongst people living with dementia and their family members, including the identification of key points on the pathway of diagnosis and post-diagnosis that may impact on individuals' mental health.

**Keywords:** Defeat, Entrapment, Dementia, Caregivers, Socioeconomic Deprivation.

## Facial Image Analysis in Health Studies

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### Abstract

Facial structural features can reflect people's health states. Certain diseases alter the appearance of the face because the disease process relates to the development or physiology of the face and affects its structure. The importance of dynamic facial features has also been recognised in health studies. There is growing evidence to suggest that dynamic facial features correlate with our health. Research has suggested the existence of abnormalities of facial expressions (spontaneous and involuntary), eye tracking, and eye blink rate in certain diseases, such as Parkinson's disease, Dementia, Schizophrenia, and other mental disorders. Such diseases alter the facial expression and structure because the disease process limits the development and ability of the face to show facial expressions. The expressions of people with Parkinson's disease and Schizophrenia have significantly reduced spontaneity, intensity and frequency compared to healthy controls. In addition, studies show that reaction time was longer in patients with Parkinson's disease than in healthy people for horizontal saccadic gaze and finger movements.

Various technologies for facial image processing have been used to analyse findings from health studies. FACS is one such tool, a technique developed by Katsikitis, allows users to select certain facial feature points, thereby using distance-based features to quantify facial expressions. Kring et al. developed a Facial Expression Coding System (FACES) providing intensity, frequency, and duration of positive and negative facial expressions. Moreover, Leonard et al. developed a novel computer imaging methodology, which was further developed by Richardson et al. This technique is based on the premise that changes in light reflectance patterns naturally occur when the face moves. These reflectance changes can be quantified by computing differences in pixel intensity, enabling us to capture micro-expressivity. This technique has been used in studies of subtle expressions in patients with Parkinson's disease.

The health related information conveyed by the face has played an important role in health studies. Consequently, technologies for facial image analysis have huge potential in health studies. The 3D image capturing process is becoming cheaper and faster, therefore there are more opportunities for researchers interested in health studies to work directly on 3D face models. Potential future uses include 3D image analysis in cranial anthropometry and state-of-the-art technologies for facial image analysis in the study of health.

Given these findings, are our facial expressions, movements, and signals underlying internal health states, perhaps Alzheimer's disease? Given these technologies, is it possible to detect and extract useful facial expressions and/or spontaneous micro-facial expressions? These questions inspire me to conduct a feasibility study that discovers relationships between facial expressions and the physical characteristics and personalities of healthy older people. Further studies could be extended to investigating if change in internal health states manifests any significant facial movements; whether or not older people with age-related memory loss could exhibit facial characteristics/abnormalities?

**Keywords:** Facial Analysis, Static Facial Features, Dynamic Facial Features, Facial Expressions.

## Telecare and Older People's Social Relations: Case Studies of Two Communities in Shanghai

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### Abstract

Long term care is a universal challenge, being addressed in almost all countries. Population ageing is a major factor in the growing demand for long term care. China has the largest population in the world, and its ageing population is putting considerable pressure on its arrangements for long term care. Further, China is undergoing a period of transition; traditional family care arrangements are proving difficult to sustain, but there are insufficient residential places (for example in nursing homes) for people with long term care needs. Against the backdrop of an aging population and social transition, developments in technology to enable older people with long-term conditions to stay at home have become a major concern in China. There is strong policy and market interest in the role telecare can play in supporting for older people more effective in the future in China.

Most research on telecare focus on the way different kinds of telecare applications support older people to remain independent and safe at home. However, telecare can also work as a powerful tool to connect people: the older person, their family members, friends, care workers, homecare agencies and so on. It operates as a means of communication connecting multiple social actors in the situation. This study focuses on the role of telecare in connecting older people and the other social actors in their everyday lives. Thus, more attention is paid to the use of information and communication technologies.

Qualitative research methods are adopted to examine older people's social relations and how telecare fits into and affects them. Data was collected through Everyday Life Analysis, by combining both longitudinal aspect and a holistic but person-centred approach which has been proved a good research method to analyse the social network of older people. Through this method, a whole picture of the older person's life will be painted, including: their full set of relationships and sources of support, their preferences, chosen activities, attitudes and aspirations towards telecare. In-depth interviews with stakeholders and focus group with care workers are also included in this study, in order to produce a comprehensive and deep understanding of the broader context of telecare usage.

The results show that the usage of telecare among older people in China is still at an early stage. The amount of older people who use telecare is very limited. The use of telecare is heavily affected by older people's abilities, interests and social networks. Older people's social networks could play an important role in supporting their use of telecare at every stage, from acquiring and installing equipment to utilizing and repairing it. Most older people has a positive view towards their experiences of using telecare. Local authorities and NGOs play a leading role in the development of telecare, such as establishing telecare centre and smart community, providing telecare training for older people.

**Keywords:** Telecare, Older People, Social Relations.



## Healthy Indoor Environmental Design for Urban Ageing Population

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### Abstract

The World Health Organisation (WHO) defines health not as merely the absence of ill-health but as “a state of complete physical, mental and social wellbeing”. A healthy building design is particularly of importance for the elders who are more vulnerable and socially isolated, and they spend more time indoors compared with the young adults. This is also an increase of aging population world-widely. The proportion of persons aged 60 years and older to the total population is expected to double between 2007 and 2050, and reach 2 million by 2050. Staying healthy in your home and in your community especially for the elders is the way to limit the increasing pressure on health services, and thus designing the home, neighbourhood and work environment to improve health and well-being is an opportunity that presents itself.

The association between health consequences and home characteristics has been widely studied, however, the building design interventions/strategies toward a healthy indoor environment for aging population are largely under-researched. I would like to give a state-of-art review on this issue from the perspective of a building environmental engineer and designer, bridging the gap between the design and health science. The links between design strategies and various health consequences in terms of physical, mental and social health will be explained. I will also particularly acknowledge the important/promising role smart technologies/ICT have played/will play in better creating and promoting a healthy indoor environment. Healthy indoor environmental design is never a trivial task, but requires multidisciplinary efforts drawing from architects, engineers, ICT and IOT and health experts.

**Keywords:** Healthy Building, Smart Ventilation, Indoor Air Health, Well-Being, Aging Population.

## New Business Models and New Market Development for eHealthcare Businesses in the Market of UK National Healthcare Sector

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### Abstract

Demographic trends with extended life expectancy are placing increasing pressures on the UK state-funded healthcare budgets. EHealth technological innovations are expected to facilitate new avenues for cost effective and safe methods of care, for enabling elderly people to live independently at their own homes and for assisting governments to cope with the demographic challenges. However, despite heavy investment in these innovations, large scale deployment of eHealth continues to face significant obstacles and lack of sustainable business models (BM) is widely regarded as part of the greatest barriers. Through various empirical methods which include facilitated workshops, case studies of relevant organisations and user groups, this paper investigates the reasons the private market of eHealth innovations has proved difficult to establish and it develops a framework for sustainable BMs that could eliminate barriers of eHealth technological entrepreneurship.

Our analysis from the perspective of diffusion of innovation (DOI) theory showed that while there have been heavy investments in eHealth innovations, adoption process is still in its early stages. While effective eHealth innovations certainly exist, they are generally run by local champions and are mostly state funded. Presently, almost no eHealth applications (innovations) have been successful in reaching enterprise-wide and large scale adoption. Various barriers to adoption of eHealth innovations were investigated in this paper and suggested solutions were prescribed. Through DOI theory, integrated strategic frameworks for sustainable business models that could make commercialisation of eHealth products and services more effective are then presented in an organised manner. Our case studies and their analysis give various insights into commercialisation of eHealth and strategies for driving these innovations through the '**Diffusion Chasm**' into the mainstream markets by segmenting users into different populations based on individual innovativeness. We provided various characteristics of individuals (elderly people) in each segment of potential eHealth users as well as suggested strategies to reach them. Our approach suggests that business model and diffusion of innovation theory are complements but not substitutes. That is, to achieve profitability, the product innovation aspects of the eHealth BMs need to satisfy all the innovation diffusion characteristics as highlighted in DOI.

Through the interviews of elderly people focus groups and facilitated workshops, our investigation discovered that compelling "**relative advantage**" is the most important factor of the DOI characteristics that could motivate the elderly people to pay for eHealth innovations despite the freely available NHS services. Other DOI characteristics mentioned are "**compatibility**" and "**complexity**". While relative advantage and compatibility are positively correlated to the diffusion of eHealth innovations, complexity is negatively correlated. This is because most elderly people did not grow up with advanced technologies and therefore tend to avoid complex gadgets.

In conclusion, eHealth innovations might have important roles as part of the strategies for the management of long term conditions and delivery of effective health and social care services to enable independent living for older people. However, the services will only become meaningful to the general public when the business models are sustainable such that they will provide mutual benefits for providers and the users.

**Keywords:** eHealth, Assistive Technology, Business Model, Telecare, Telehealth, Telemedicine.

## Employment of Emerging Technologies as Assistive Digital Healthcare for the Older Population

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### Abstract

The ageing population of 60 years and over, is currently about 10% of the global population. It is expected that by 2050, this will increase to 20%. It is recognised that ICT shows great potential in enhancing the life's of the older population. The European Commission has recognised the importance of this issue and has funded the Active and Assisted Living (AAL) programme under the Horizon 2020 framework. This was also further corroborated in the UK Government for Science's "Future of an ageing population: evidence review" series of foresight report.

Over the years, there have been significant research development into the adoption of ICT (Information and Communications Technologies) in healthcare, however, it is widely recognised that technological acceptance for healthcare lags significantly decades behind other industries. In recent years, due to the availability of emerging technologies, such as robotics, mobile applications, Internet of things (IOT), cognitive system and sensors, there is an opportunity to further advance the digital strategy in healthcare. Digital healthcare could facilitate and improve all sector of healthcare from patients' self-care, assistive tools for healthcare professionals and organisations.

In UK, from 2011 to 2013, approximately an average of 34,500 new cancer cases (excluding non-melanoma skin cancer) were confirmed annually [1]. Moreover, approximately 76% of the confirmed cancer cases were aged 60 and above, with the male population consisting of 54% and the remaining 46% are female. Cancer patients faces significant challenges and changes in their lifestyle, especially older patients that are living independently. During the course of a cancer patient's treatment, their health, physical, mental and emotional state will inevitably deteriorate and be affected. This includes the possibility of mild cognitive impairment and a higher potential of falls occurring in older cancer patients during the course of their treatment, such as chemotherapy. In [2], an investigation into supporting advanced cancer patient living at home was presented and an aspect of the study looked into using assistive devices for patient's daily activities. However, details on what assistive technology or devices that was employed was not specifically described. In another study, see [2], the development of a mobile web application was developed to encourage older cancer survivors to engage in regular physical activities. The application also allows users to set their physical activity goals, track their progress and gather feedback. The study stated initial efficiency in the application, but this assumption seems limited due to the small sample size of 30 participants.

Therefore, in this presentation, a discussion on the prospect of employing emerging technologies, such as mobile application, IOT, to enhance the *modus vivendi* and well-being of older cancer patients will be presented. Moreover, the potential of using technologies to aid in the decision making process on the course of treatment options for cancer patients will also be discussed.

**Keywords:** Emerging Technologies, Assistive Digital Health Care, ICT, Older Population.

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## Socio-Technical Challenges Associated with the Adoption and Usage of Assistive Technologies and Smart Homecare Solutions for Older People

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### Abstract

As a technology-oriented social scientist, my research has a particular focus on the social, cultural, political, organisational, and environmental aspects related to the uptake of innovative digital and ICT technologies in future smart cities. In the area of healthcare, I am particularly interested in how smart and assistive technologies and solutions (e.g. those combine the technical components of wearable devices, iBeacons, big data analytic tools, smartphones, and/or mobile apps) can be used to address the global ageing population issue, by supporting the needs and providing better care services to the elder people as well as to treating their chronic diseases (e.g. dementia and Parkinson) in both indoor and outdoor environments. My research in this field has also focused on cultural differences, individual needs, legitimate issues, and other related socio-technical challenges in the UK and Chinese context. In light of this discussion, my research has a strong interdisciplinary nature, which fits very well with the scope of this workshop. Furthermore, I have a very strong publication record, i.e. since 2008, I have produced over 67 international publications, including 17 high-quality journal articles (of which 10 were published in SSCI/SCI/EI journals), 2 books, 9 book chapters, 5 edited conference proceedings, and 28 full-refereed conference papers. I have also led or been involved in 10 research projects totalling around £360,000 (3.6 million RMB), funded by research councils like ESRC and EPSRC, industrial partners, Sheffield University in the UK, and NSFC in China. In March 2016, I led a consortium (involving two universities and two large organisations respectively in the UK and China) to work on and submit an application to the Healthcare theme of the China-UK Newton Fund Research and Innovation Bridges competition, with a total funding amount of £1.7 million. Overall, I believe my insights, expertise and strong research track records will allow me to make meaningful contributions to the workshop. On the other hand, I believe that this workshop will be an excellent opportunity for me to extend my existing research network in both the UK and China. More specifically, by attending this workshop, I expect to meet other outstanding researchers, from different disciplines but with similar research interests, with whom I can build up long-term research collaboration. Further to these, I believe this workshop will be an excellent knowledge sharing opportunity, from which I can enhance my knowledge and learn the latest research outputs related to the development and usage of assistive technologies. I expect some cutting-edge research ideas will come up from this workshop, and I recognise that there will be high possibility for me to explore these ideas further with new colleagues who I am going to meet in the workshop.

**Keywords:** Social-Technical Challenges, Adoption, Usage, Assistive Technologies, Smart Homecare, Older People.

## Designing Digital Support for Vulnerable Individuals

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### Abstract

We are surrounded by exciting innovations in technology which allow us to continually sense, monitor and inform us about ourselves and our environment. However, effective uptake and use of smart technology, sensors and mobile communications for health and well-being demands a complete shift in perspective. We need to bring together researchers and innovators from many different fields of expertise in order to create solutions which are not just multidisciplinary, but truly transdisciplinary, taking into account the whole environment in which people live. More than this, we need to design not just **for** the ageing population, but **with** them, creating solutions which are efficient, effective and, most of all, acceptable.

I have degrees in rehabilitation and computing, and a PhD in Creative Technologies, and this multidisciplinary background is the driver for my research focus, which is on the use of interactive technology for health and well-being. I work with virtual reality, serious games and mobile applications to explore innovative solutions to societal challenges. Recent projects include:

**Responsive Interactive Advocate (RITA)** ([www.rita.me.uk](http://www.rita.me.uk)). For this project we were tasked to explore radical solutions to support the isolated ageing population. Around 3 million over 65's in the UK live alone, with more than half suffering long term health/mobility issues. Individuals within this demographic may consequently possess limited companionship opportunity as some of their peers have passed away or are similarly ill. Whilst they may be fortunate enough to have a family, personal and lifestyle pressures may restrict opportunities for support and care. Professional carers may also be available, but only visit for relatively brief periods, meaning that the majority of the individual's time may be spent in isolation, causing them to experience disengagement, frustration and a lacking of fulfilment and purpose. Furthermore, loneliness and isolation is known to have a detrimental effect on health, causing rapid deterioration and early institutionalisation. We have been working with dementia patients, carers, the elderly well, housing providers and care professionals to develop a prototype of a virtual companion (avatar) to monitor physical and emotional health and provide conversation and support. The avatar is designed to be deployed both within the home and on mobile devices, providing continuity of experience both inside and outside the home.

**Co-Designing Care** ([www.codesigningcare.com](http://www.codesigningcare.com)). In this project we are exploring how technology can support young people in care to stay safe; recognise and manage their emotions and behaviour; and communicate more effectively with practitioners. Vulnerable young people share many characteristics with the elderly. They are often isolated and disconnected from family and friends, with complex wellbeing needs. Emotional and physical safety is vitally important, but they often put themselves at risk of harm. Effective solutions need to put empowerment of the individual at the centre. We are using the Design Council Double Diamond approach, involving end users, carers, local authorities and social workers to identify needs and map them to potential technological solutions. We have already developed a number of technical prototypes designed to run on a mobile platform and communicate with other devices and applications, including an application to map emotional state over time and geographical location, identifying areas within the social space which are associated with positive or negative emotions. We are also exploring the integration of geolocation and personal schedules, to support safe independence.

**Keywords:** Healthcare Avatars, Serious Games, Co-Design, Interactive Technology, Virtual Reality.



## My Potential Contribution towards the Researcher Link Workshop

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### Abstract

I believe my background differs from most of the participants but my first job is computer sales in 1990, when most PCs were equipped with 8088 CPU and big floppy; colour monitor, hard disk, even mouse, were kind of luxury purchase at that moment as Windows was at its infant stage. I later worked in intelligent control companies so I have reasonable IT skills and knowledge although am not a programmer or a hardware engineer.

With a PhD from Built Environment School and working in Business School, I can contribute with my multi-disciplinary experiences and knowledge across academia and industry, which is important for evaluate advances in engineering from sustainable business perspective. I am currently involved in a £0.8 million research projects funded by EPSRC in built environment discipline with a focus on Business Information Modelling. My contributions towards this research project lie in my built environment background and project management skills (I am a Fellow of Association for Project Management). I have submitted three funding applications to Innovate UK in the past 12 months and one to ESRC early this year, and I am confident that I can work with some colleagues from this workshop in future funding applications. Through the years since 1990 I have witnessed the advances in ICT and their implementation in industrial and domestic markets. I am still well connected with the practitioners in this field and fascinated with how technologies change people's life, which is prominent in funding applications.

Innovation, sustainability and project management are part of my research interests which enables me to evaluates social, economic and environmental impacts of proposed projects and innovation. With my research interests in knowledge management and communication style, I am also interested in how the interfaces of new ICT technologies should be designed to align with and reflect preferred communication styles in different cultures. For instance, Chinese language is categorised as a high-context culture, which implies that the meaning of a sentence is heavily dependent on its context. The implications of this observation should be reflected in the design and implementation of ICT technologies in order to minimise misunderstanding and provide user friendly technologies.

In addition, with my PhD in construction project management and my professional qualifications in project management (APMP and Practitioner Qualification from APM), I am confident I can contribute towards project management aspect such as project planning and team building, integrating expertise across a range of disciplines, which is essential for any research and innovation project success.

**Keywords:** ICT, Knowledge Management, Communication Styles, Project Management, Funding Applications.



## Addressing the Needs of Dementia Patients' Carers: A Segmentation Exercise to Ensure Long-Term Wellbeing

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### Abstract

Societies and healthcare structures around the world are increasingly facing the trying issue of providing for dementia sufferers. However, in most cases, once a diagnosis of dementia has been formulated, the care and comfort of a patient fall upon a family member or another non-professional carer. With the progression of the condition and the exacerbation of the symptoms, the burden on the carer increases exponentially, promoting the onset of anxiety, loneliness and even depression in an otherwise healthy person; in many cases this can result in the need for secondary care measures directed at the carer and, therefore, in substantial additional strain on national health systems.

The aim of this research is to identify and address the needs and concerns of dementia sufferers' carers during the early stages of their role to enable healthcare professionals to apply preventive rather than reparative measures. This will be achieved through a three-phase, mixed-method study based on: a) an exploratory phase (Phase 1) during which data will be collected from online dementia forums, and subsequently structured and analysed using text mining and qualitative data analysis software (e.g. NVivo); this will be carried out to extract fundamental themes and outline attributes for profiling and identifying the most suitable type of segmentation; b) a phase of primary data collection (Phase 2), which will involve the distribution, within dementia forums, of a quantitative research instrument with careful constructs formulation, aiming at channelling and refining carers' potential segments and c) a final phase (Phase 3) involving qualitative, in-depth interviews with selected respondents to the questionnaire to further explore specific insights and clarify possible areas of uncertainty.

This research will identify a number of "segments" in the carers population in terms of factors such as attitude, demographics, need and behaviour. Each identified segment will aggregate people who have common needs and that will respond similarly to an action. The number and type of segments will be refined until a satisfactory segmentation framework is identified.

In addition, a typing tool will be informed from the quantitative data collected. Such tool will be based on a set of questions to ask dementia patients' carers to evaluate their emotional state, the extent and efficacy of their support network and their day-to-day needs and to enable healthcare professionals to offer them personalised solutions. The adoption of this tool on a large scale could improve the living conditions and long-term wellbeing of people looking after patients of a chronic, non-communicable disease such as dementia.

This study will take place in both China and UK to provide a) each country with a tailored typing tool and possible segmentation of their carer population and b) to compare the carers' status in the two countries and highlight the differences due to tradition, culture and economy.

**Keywords:** Dementia, Carers, Segmentation, Typing Tool, Mixed-Method.

## Fall Prevention using Wearable Robots

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### Abstract

Falls in ageing populations represents a global challenge. Between 22–60% of older people suffer injuries from falls, 10–15% of which are serious. Recurrent falls are associated with increased mortality, increased hospitalization and higher rates of long-term care. In response to this global challenge, part of our research aims to develop a novel wearable robotic system for fall prevention and assisted motion in day-to-day life.

This system is comprised of a set of wirelessly-connected small actuation devices worn on lower limbs under clothes. The system benefits from a highly detailed subject-specific biomechanical dynamic model and an autonomous control system to monitor the subject's movement and environment, learn subject-specific motor control patterns, predict near future movements and finally use all these to aid harmonious motion, avoid instability and falling or recover balance by applying corrective torques on body joints while in motion.

Such a system has the potential to transform the lives of millions of people that are dealing with movement problems and/or have a high risk of falls in their everyday life. The operative word in this research is 'practicality', making it possible for people to use the technology in day-to-day life. This type of system has many applications beyond fall prevention, movement aid, health monitoring and rehabilitation; for example, it can be used in powered prosthetics and wearable robots for use by sports men and women, emergency services, first responders and military personnel.

In this workshop, I hope to be able to speak to colleagues and health and industry representatives to share about our experiences and learnings along the way, learn about new ideas, applications and future trends and consult about strengths and challenges of research/development in this area and possible avenues to overcome these challenges. We are looking to find potential partners, supporters and collaborators, in health sector, academy and industry:

- To develop technological platforms/systems/equipment required for the large-scale dissemination of the movement monitoring system developed in our research and to build infrastructures required for Big data analytics with mutual benefits for all involved parties particularly users;
- To collaborate in future research projects particularly for the wearable assistive robot research theme;
- To explore the possibility of attracting industrial money for future research and development.

**Keywords:** Elderly, Balance, Assistive Robots, Predictive Dynamics, Big Data, Continuous Monitoring.

## Dependability Analysis for Remote Healthcare Systems and Clinical Workflow Designs

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### Abstract

In parallel with the growing demand for personalised non-hospital based healthcare system to improve the provision of chronic disease management, the adoption of home-monitoring systems has been growing in the recent years. Ensuring the safety and reliability of such system architecture is important. System failures may result in catastrophic consequences, for example delayed or absence of a critical treatment, which may subsequently put patient's life at risk. This research explores the application of Model-based Safety Analysis (MBSA) techniques which are prominently used in other safety-critical industries to analyse the dependability of remote-monitoring system architecture and clinical workflow. Hierarchically-Performed Hazard Origin and Propagation Studies (HiP-HOPS) and model checking can be systematically applied to enable safety analysis and verification of the system. HiP-HOPS is a state-of-the-art technique which enables automated fault tree synthesis and analysis, Failure Modes and Effects Analysis (FMEA) and system architectural optimisation. The approach utilises a compositional process to construct the predictive system error models from the topology of a system and the error models of the components. The analysis results facilitate the identification of the root causes for a hazardous failure. This subsequently allows identification of design weakness, high-priority critical components, and provides useful guidance for the design iterations and improvement. When component variability is available, automated optimisation can also be performed; this helps identify the optimal trade-off between objectives (e.g. dependability and cost). Model checking is a formal verification technique which uses exhaustive exploration of system behavioural models to assess the conformity of the model to the safety requirements. The effects of failures on system level are observed by injecting faults into the formal specification. System behaviours can be modelled using finite state automata, and the requirements can be expressed in temporal logic. Preliminary work has investigated the application of HiP-HOPS and showed its contribution in the analysis of a diagnostic algorithm for a home-monitoring system. The application of the approach in a hospital Radiology workflow also evaluates the safety of the workflow design in an operational setting. The process identifies the failures (and the combinations of failures) which may lead to patients developing unintended reactions due to the administration of the contrast media. This safety analysis process can be employed to assess the design of care provision infrastructure or treatment workflow for elderly patients. Our work also explores the combined use of Complex Event Processing (CEP) and HiP-HOPS, particularly in the context of failure management. Application of CEP facilitates the collection and processing of vital data from sensors. CEP can be used for the monitoring of nominal (expected) and failure events, pattern detection, and event processing. Failure expressions identified from HiP-HOPS analysis can be consulted in the construction of CEP rules, which in turn allows the detection of critical or failure events and enables responsive actions to be triggered.

As the use of wearable sensors and assistive technology become increasingly prevalent in the effort to improve the well-being and care provision around the cities and homes of elderly, potential risks need to be evaluated and managed. The systematic application of these MBSA techniques enables a robust, incremental safety-driven design process.

**Keywords:** Safety Analysis, Reliability Engineering, Architectural Optimisation, Clinical Workflows, Telehealth, Model Checkin.

## Building People Bridges to Embrace UK and China's Science Collaboration in Advanced Materials

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### Abstract

Working as an International Collaboration Manager for the Polymer Interdisciplinary Research Centre (IRC) of the University of Bradford, I have more than 10 years' experience in establishing, developing, and managing a portfolio of multimillion pound strategic international research and knowledge transfer collaborations.

The Polymer IRC at Bradford is a world leading research laboratory for process structuring of polymers, polymer composites/nanocomposites, biomaterials and pharmaceuticals, with novel and conventional materials processing. We are also one of the five founding members (others are Universities of Leeds, Newcastle, Nottingham and Sheffield) of the national Centre for Innovative Manufacturing in Medical Devices (MeDe) that funded by the EPSRC and is part of a wider programme of support for innovative manufacturing research centres. MeDe researches and develops advanced design and manufacturing methods for the Class III, musculoskeletal medical device sector. Since launched in 2013, the Centre has leveraged £20m industry support further to its initial £6m grant.

Within the Polymer IRC, our major collaboration partner country is China. Our RCUK funded £1.27m Science Bridges China platform, of which I am programme managing, is an international research platform in advanced materials for healthcare, which in collaboration with five leading research institutes at the University of Bradford, namely the Centre for Advanced Materials Engineering, the Centre for Polymer Micro and Nano Technology, the Centre for Pharmaceutical Engineering Science, the Institute of Cancer Therapeutics and the Centre for Materials Chemistry. It brings together scientists, companies and hospitals from the UK and China to develop areas in drug discovery, drug delivery and medical technology. This programme consists of collaborative research, development and open innovation in pharmaceuticals and healthcare. It brings together scientists and companies from the UK and China to develop new therapies, medical diagnostics, advanced materials for drug delivery materials and medical devices. To date, the programme has achieved total cash support of around £8m, and substantial in-kind support in the UK and China. It has funded 26 joint research projects, more than 40 research exchanges between UK and China, 2 jointly supervised PhD students, 2 international joint labs. There are more than 20 high quality joint publications produced, and 4 international joint patents filed. 9 international research workshops were hosted. In 2012, it has established the UK-China Advanced Materials Research Institute, which has more than 200 members.

Besides my interest in developing research collaborations in advanced materials for medical devices for aging population, particular ICT applications as my own research interest is in telecommunications, I am also interested in developing an understanding in how to succeed in international research collaborations between UK and China, with a focus on healthcare sector. The later will form the research topic for my current part-time Doctorate study in Business Administration.

**Keywords:** Science Bridges China, Advanced Materials, Medical Devices.

## Coproducing Digital Platforms to Support an Ageing Population

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### Abstract

What can we learn from our experiences of building digital platforms that can help us address the challenges of maintaining the health and wellbeing of an ageing population? In this talk, I will focus on how our research at the Health eResearch Centre (HeRC), University of Manchester, has increased our understanding of the technical requirements and solutions required to enhance the health of older people, and specifically people with dementia. I will discuss the promises and the challenges of using mobile and wearable technologies to address the ageing demographic. The talk is structured around three areas: data capture; integration with existing medical devices and medical systems; and coproducing healthcare with patients and clinicians. I will illustrate the challenges of each area using examples from projects developed by the mHealth team at HeRC.

Firstly, addressing data capture, I will discuss two digital platforms developed at HeRC, which use active and passive data capture techniques respectively. The ClinTouch platform (<https://www.clintouch.com>) employs active data capture techniques, and was designed to support people with severe mental illness to self-manage their condition by asking them to record their symptoms on a mobile app at pseudo-random intervals throughout the day. Passive data capture is used in the CFHealthHub system (<https://www.cfhealthhub.com>), in which patients with cystic fibrosis are supported to adhere to treatment by enabling automatic data transfer from their nebulisers, and making these data visible to patients and clinicians in meaningful and actionable ways. I will describe why each approach was adopted and the benefits of combining approaches to maintain the health of older people.

Secondly, I will identify the benefits and barriers encountered in our work integrating with medical devices and medical systems. The Dementia Sensing Platform (part of the larger national DPUK project: <http://www.dementiasplatform.uk/>) was designed to allow data from as broad a range of wearable, mobile and medical devices as possible to be securely collected and stored. I will discuss the trade-offs between providing a 'device-agnostic' technical solution and enabling fine-grained actionable visualisations and analyses of the data collected. In terms of integrating with medical systems, the diversity and complexity of electronic health records used across hospital settings in the UK renders it difficult to develop a 'one size fits all' approach; I will discuss how we have approached this integration challenge across a range of projects and the implications of our findings for technical projects aiming to support people with dementia.

Thirdly, I will discuss how a key element and ethical commitment of our work involves the coproduction of technical solutions with patients, clinicians and members of the public. All of our digital projects are committed to patient and public involvement (PPI) in healthcare research, and I will describe the iterative, agile methodologies that we use as a technical team to support this approach. I will provide some examples of how patient and clinician feedback has shaped and refined requirements of the technical solutions developed, highlighting specifically the requirements identified by people with dementia in our PPI research for the Dementia Sensing Platform.

Situating this discussion within the broader health informatics landscape of Northern England, I will outline how the work of HeRC connects with recent developments in Greater Manchester and beyond, including the Connected Health Cities initiative, the Greater Manchester Academic Health Science Network and the NewMind Plus Network.

**Keywords:** mHealth, Wearables, Mobile Apps, Smartphones, Dementia.



## Broadening Our Understanding of Good Home Care for People with Dementia

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### Abstract

Based on research conducted with two branches of a home care franchise in Nottingham, UK, this presentation introduces the BOUGH study, a project seeking to Broaden Our Understanding of Good Home care for people with dementia. 'Home care' refers to a range of care and support interventions delivered to people in their own home: domestic tasks, shopping, home maintenance, personal care, enabling access to the community, social activities, rehabilitation and recovery, and support for people who are dying. It can be preventative, providing companionship, engagement or early intervention to avoid a deterioration in health and wellbeing. The BOUGH study is timely, since, in the UK, two thirds of people with dementia live in the community (Alzheimer's Society, 2016). Most home care in the UK is provided by the independent sector (89% in 2012, compared to 5% in 1993) (Community Care Statistics, 2013).

This research aims to understand what quality means in home care for people with dementia, in order to raise standards and improve value for money. This project investigates the interpersonal dynamics, scope and nature of good quality home care for people with dementia so that it can be more widely implemented. BOUGH aims to examine home care for people with dementia so that its function in community support can be described fully. The research investigates the interpersonal dynamics, scope and nature of home care for people with dementia, in order to improve the experiences of those receiving care.

This project combines several methods of data collection and analysis, including: participant observation with clients with dementia and their family carers; interviews with home care workers; interviews with present clients and family members of past clients; diaries undertaken by home care workers; and telephone interviews with commissioners of home care. This paper focuses on the participant observation element of the study, in which two researchers underwent full training to become home care workers, and became embedded in two home care organisations, working 'hands on' as home care workers for people with dementia in their own homes.

After a period of independent fieldwork, both visiting clients individually to provide care, and shadowing calls with existing home care workers, the team collectively categorised the data into topics and themes. This paper presents some preliminary findings which have emerged from this team ethnography, surrounding the themes of: managing relationships with family carers; negotiating alcohol consumption; and the lifestyle impact of being a home care worker. It is hoped that by elucidating some of the lived experiences of those with dementia, and their care workers, this presentation can provoke thought for how information and communications technologies can be productively employed in homes and cities for the health and well-being of older people.

**Keywords:** Care Workers, Dementia, Home Care, Participant Observation.



## CONTRIBUTIONS FROM CHINA

Comprising 23 abstracts from 7 CHINA Institutions

## Role of microRNAs in nonalcoholic fatty liver disease and aging

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### Abstract

Nonalcoholic fatty liver disease (NAFLD) has become the most common form of chronic liver disease worldwide. Nonalcoholic steatohepatitis (NASH), the hinge between steatosis and cirrhosis in the spectrum of NAFLD, could be present in one third of NAFLD cases. Aging is characterized by a progressive loss of physiological integrity that occurs through the accumulation of macromolecular and cellular damage, leading to impaired fitness and increased vulnerability to death. This deterioration is the primary risk factor for major human pathologies, including cancer, diabetes, cardiovascular disorders, and neurodegenerative diseases. The prevalence and severity of NAFLD/NASH appear to increase with age. Although cases with cirrhosis are now occasionally diagnosed in young adults, cases with liver complications are more often in the 6th through 8th decades of life. This finding could be related to increasing rate of fibrotic progression with age or to mitochondrial dysfunction (which causes steatosis and hepatic insulin resistance) developing in the elderly. Whereas, the exact pathogenesis of NAFLD/NASH and the underlying relation between NAFLD/NASH and aging remain obscure.

The recent discovery and functional characterization of microRNAs has substantially changed the classic view of gene expression regulation and has unveiled a new group of molecules that contribute to the complex process of aging. microRNAs are small RNA molecules that directly bind to the 3' untranslated regions (3'UTRs) of their target transcripts and inhibit protein production by mRNA degradation or translational blockage. microRNA-mediated regulation is an extended phenomenon across animals and plants, which has the ability to control a considerable proportion of cellular transcripts. In humans, over 1000 microRNAs have been validated and it has been estimated that more than 60% of transcripts are susceptible to microRNA regulation. Individually, each microRNA has the potential to repress tens to hundreds of transcripts, a feature that allows them to modulate the levels of several components of a single pathway or to affect the activity of related pathways through the regulation of different key elements. In addition, their frequent organization in genomic clusters that coexpress different microRNAs further increases the range of potentially targeted pathways and functions. Thus, these molecules play important roles in almost every process of the cell, such as proliferation, differentiation, migration, apoptosis, senescence and autophagy. Likewise, microRNA activity is essential during embryonic development and in numerous physiological and pathological processes, including aging.

In our previous studies, miR-194 was found to be upregulated in NAFLD. To explore the pathogenesis of NAFLD, we are studying the role of miR-194 on the glucose and fatty acid metabolism in normal or steatosis hepatic cells. And the effect of miR-194 dysregulation on the protein level of pyruvate dehydrogenase E1- $\beta$  (PDHB) in hepatic cells will be evaluated. This study is trying to demonstrate the regulatory roles of miR-194 in the hepatic energy metabolism and the pathogenesis of NAFLD, and to provide clues for new therapies of NAFLD. Further studies on the connection of NAFLD/NASH with aging and the potential role of microRNAs involved are underway.

**Keywords:** Nonalcoholic Fatty Liver Disease, Nonalcoholic Steatohepatitis, Aging, microRN.

## Research on Indoor Location Based on Machine Learning for Health Care

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### Abstract

Wireless Location has played an increasingly important role in modern society, with its applications in wide areas such as the traffic, business and indoor health care for old people. Unlike the triangle location which is degraded its performance by signal's NLOS (Non-Line-of-Sight) and multi-path propagation environment, we assume that for the single BS location, the complex multi-path are in favour of the location, because the multi-path environment provides the unique "fingerprint" for every individual place. If handled well, method based on machine learning can utilize these characters and make the location no longer limited to the signal's LOS condition. Our work focuses on single BS location based on the machine learning method in the MIMO mobile communication system, and also aims to resolve problems in the location progress, such as the channel model building, the building and selection of the "fingerprint", the communication standards analysis and channel estimation.

While previous channel models for single base station location were based on distributed scatters environment, this article uses the ray tracing method to simulate the spreading channel. In the knowledge that the SCM(Spatial Channel Model) model belongs to geometry statistical channel model, and the geometric statistical channel modeling is the reduction of ray tracing model, this article combines the ray tracing method with SCM to create a channel model for location simulation. We establishes the channel model and get the data of the signal's path delay and angle information between source and field point. We also collect the radio signal data in real environment. The real environment signal is used to compare the simulated channel model. These data resource make the foundation of location.

As an attempt the signal's angle of arrival is used as the first kind of fingerprint. The traditional algorithm of signal angle estimation required the second or higher order statistics of received signal matrix, which required large amount of received data and a long-time computation. We presents an MIMO channel angle estimation algorithm based on phase differences, utilizing phase differences of channel impulse response between the transmitting antennas (or receiving antennas) to estimate angle of arrival (or angle of departure) . Compared to the traditional subspace decomposition algorithm, the number of antennas of this algorithm is not restricted by the number of signal sources, and the algorithm has less computation amount.

After that, we provide a single BS location method based on Support Vector Machine (SVM). We firstly researched theory of machine learning location, and then propose the location application of SVM in MIMO communication system. It focuses on the theory of SVM location and discusses its simulation performance. By comparing whether the measured angle information takes part in location simulation, it reveals the angle of channel's great importance in location application. By comparing the localization performances of three machine learning methods, it reflects the superior performance of SVM over the classical triangle location method.

Then, the received signal's power strength is also combined with arrival angle as a new fingerprint. We also use the SVM as a base machine learning method. We try to use the SVM to find the relationships between the arrival angle, signal power strength and individual place. After multiple experiments we find that the relation is not obvious. Cause the power strength is not a steady measurement. This suggests we must develop a new signal character, with less fluctuation amplitude, as the component of the fingerprint.

**Keywords:** Location, Fingerprint, Machine Learning, Non Line of Sight, MIMO.

## Distributed Sub-Nyquist Sampling in Wireless Sensor Networks

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### Abstract

Compressed sensing (CS) is a hot issue in recent years because of its sub-Nyquist sampling rate. CS is suitable for processing these kind signals which have big bandwidth and data size, such as in sensing signals processing based on WSN field. Modulated wideband converter (MWC) is a proven sub-Nyquist sampling system which is developed from compressed sensing theory. It accomplishes highly accurate broadband sparse signal recovery by multichannel sub-Nyquist sampling sequences. However, when the number of sparse sub-bands becomes large, the amount of sampling channels increases proportionally. Such hardware cost is unacceptable to a single sensing node in practical applications. In cognitive radio (CR) scene, cooperative spectrum sensing based on WSN is a good alternative to solve the shadow fading and multipath fading problems. Unfortunately, it is subject to Nyquist sampling rate in broadband signals sensing field. Based on this, we propose a distributed modulated wideband converter (DMWC) scheme innovatively, which regards one sensor node as one virtual sampling channel and combines modulated wideband converter technology with broadband cooperative spectrum sensing network perfectly. Because of a good deal of sensing nodes in a spectrum sensing WSN, DMWC can get rid of the channel-shortage problem. Besides, being different from modulated wideband converter scheme, distributed modulated wideband converter takes phase shift and transmission loss into account in each input terminal, which are unavoidable in a practical WSN application. Our scheme is not only able to recover the support set of broadband sparse signals quickly and accurately, but also reduces the hardware cost of single node drastically in the spectrum sensing WSN. Theoretical analysis and numerical simulations show that phase shift has no influence on the recovery of frequency support, but transmission loss degrades the recovery performance in different extent. Nevertheless, we can increase the amount of cooperative nodes and select satisfactory nodes to be virtual sampling channels at different transmission distance to improve the recovery performance. It indicates distributed modulated wideband converter is extremely effective in broadband cooperative spectrum sensing network. In other sensing WSN application, such as temperature sensing network or medical data sensing network, which need strict real-time capability or have large amount of data to process, our DMWC can make a contribution to these application benefitting from its sub-sampling and sensing nodes' spatial diversity. What is worth mentioning, DMWC can provide a high data security because of its pseudo-random mixing function, which is a important component in a sensing WSN. In a word, our DMWC is an effectual sub-sampling scheme in a practical sensing WSN application.

**Keywords:** Cognitive radio, Compressed sensing, Sensing WSN, Transmission loss, Distributed modulated wideband converter, Support set.

## Image Super-Resolution Technology and Its Application in Image Compression

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### Abstract

Nowadays, the aging of population has become a more and more serious problem, especially in developed countries and some developing countries. This phenomenon leads to an issue: how to keep the safety and health of the aged people in a economical and convenient way? The development of mobile communication equipment makes it possible to monitor the status of old people in real-time. To achieve this goal, one of the central issues to be addressed is the real-time transmission of images and videos. Our group have been turning to the research on image super-resolution technique and its application in image and video compression in recent years<sup>1</sup>.

Image super-resolution technology aims to recover a high-resolution image from an or a series of observed low-resolution images. In recent years, it has been an active topic in image processing due to its extensive use in many applications, such as medical imaging, remote sensing, image display, video surveillance, and computer vision. However, image super-resolution problem is a severely ill-conditioned problem as many high-resolution images may generate the same low-resolution image. Therefore, it is necessary to exploit the prior knowledge of natural image to achieve a high-resolution image with good visual quality and as similar as its ground truth. We have developed a series of image super-resolution frameworks by using natural image priors and machine learning.

At low bit-rates, the existing compression standards do not perform well due to serious coding artifacts can be introduced. Plenty of works have shown that compressing images at smaller resolution is beneficial to improving the low bit-rates compression performance, i.e., downsampling before encoding and upsampling after decoding. Therefore, the super-resolution technique can be applied to upscale the decoded image for its better performance than conventional interpolation methods. By using super-resolution method, we have proposed two low bit-rates image coding frameworks to improve the compression performance of JPEG and JPEG 2000, respectively.

In this paper, we present some of our recent works on image super-resolution and low bit-rate image compression. Firstly, a brief introduction to image super-resolution technology is reported. Then, we illustrate two single image super-resolution methods proposed by our group. Next, the application of super-resolution in image compression is introduced, and we show two low bit-rates image compression frameworks. Finally, the ongoing work and future directions in this area are presented. By introducing the super-resolution technology and its application in this presentation, we hope that it can be used in more and more practical situations.

**Keywords:** Image Super-Resolution, Image Priors, Machine Learning, Low Bit-Rates Compression.

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## Fast Transmit Beamforming with Distributed Antennas

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### Abstract

Antenna array technology is becoming increasingly important in the new generation mobile communications for its ability to increase the communication system capacity. Especially, the transmit beamforming has received much attention. Compared to a single-antenna transmission, the transmit beamforming with  $N$  antennas can yield  $10\log N$  dB gain in signal to noise ratio under the same signal power.

A challenging problem is to implement the transmit beamforming with a number of antennas at various locations significantly apart from each other, namely distributed transmit beamforming (DTBF). In such scenario, two or more distributed transmit antennas work together to form a virtual antenna array (VAA) that is able to align the transmitted signal phases at an intended receiver. Thus, the signals from different propagation channels can be constructively added up in spatial domain to achieve the enhanced signal power.

The previous methods generally focus on processing in RF domain. But practically it is advantageous to realize the transmit beamforming using DSP (Digital Signal Processing) devices in baseband domain since the baseband operation is more viable than RF operation with high frequencies, and also it is less costly.

In this article, we explore a fast convergent algorithm for the distributed transmit beamforming, which implements updates on I/Q components in baseband domain. With an iterative procedure and variable step sizes, the updates are carried out on a single antenna each time, one by one cyclically, which lead to a significant reduction on iteration times and therefore a fast convergence. The proposed algorithm applies a formula to determine the step size for the update at each iteration. With RSS feedback the algorithm can effectively track the mobile user, without requiring DOA (Direction of Arrival) estimation. Therefore, the motivation of this article is to introduce a baseband transmit beamforming algorithm for distributed antennas, that carries out cyclical single antenna updating with variable step sizes.

Simulation results illustrate the effectiveness of the proposed algorithm which exhibits a fast convergence property in comparison with that of other compatible algorithms.

**Keywords:** Distributed antennas, Baseband beamforming, Fast convergence, Transmit beamforming.



## Transformation optics for efficient calculation of transmembrane voltage induced on cells

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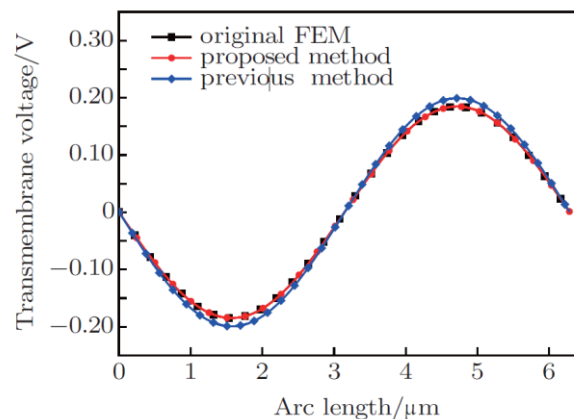
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### Abstract

We present a novel efficient approach in calculating induced transmembrane voltage (ITV) on cells based on transformation optics. As cell membrane is much thinner than the dimension of a typical cell, discretizing the membrane needs numerous meshes. Using anisotropic medium based on transformation optics, the thickness of membrane can be exaggerated by at least one order, which eliminates rigorous mesh refinement and reduces unknowns greatly. The accuracy and efficiency of the proposed method are verified by a cylindrical cell model. Moreover, the influence on ITV with bound water (BW) layers is also studied. The results show that when cells are exposed to nanosecond electric field, BW layers should be rigorously considered in calculating ITV.

Figure shows ITV across the membrane with a working frequency of 1 MHz. The black line (with solid squares), red line (with solid circles), and blue line (with solid rhombi) represent the results by original FEM, the proposed method, respectively.



**Keywords:** Transformation optics, Cells, Induced transmembrane voltage.

## Tunable release of chemotherapeutic and vascular disrupting agents from Injectable fiber fragments potentiates combination chemotherapy

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### Abstract

With increasing incidence and mortality, cancer is a major leading cause of death and is a major public health problem worldwide. Systemic chemotherapy after surgical remains a common strategies for treatment of malignant cancer to avoid tumor recurrence and metastasis. However, systemic chemotherapy usually indicates severe limitations in the safety and effectiveness, such as systemic toxicity, immunogenic injury and significant morbidity, which have heavy impacts on the quality of patients especially on the older patients. The localized drug delivery systems have been proposed to be a good strategies to overcome these challenges by releasing the chemotherapy drug to the tumor site directly, making the therapies more efficient with minimal adverse effect. In previous study, we have successfully indicated the good antitumor and nati-metastasis efficacy by local surgically implanted the electrospun fibers into tumors, which can release antiangiogenesis hydroxycamptothecin(HCPT) and vascular disrupting agents combretastatin A-4 (CA4) into tumor site. However, there are still some patients especially the older people who are not feasible for surgical implantation owing to the physical in origin such as the age, the illness of NCDs and so on. To address the issues, in this study, we developed an injectable short fibers with diameter of 20  $\mu\text{m}$  long through electrospinning and cryo-cutting. To address challenges in balancing the disruption of tumor vessels and intratumoral uptake of chemotherapeutic agents, this study is focus on release tuning of HCPT and CA4 from the fiber fragment mixtures. Hydroxypropyl-b-cyclodextrin (HPCD) was blended at ratios from 0 to 10% into CA4-loaded fiber fragments(Fc)to modulate CA4 release durations from 0.5 to 24 days, and HCPT-loaded fiber fragments (Fh) indicated a sustained release for over 35 days. In vitro cytotoxicity tests indicated a sequential inhibition on the endothelial and tumor cell growth, and the growth inhibition of tumor cells was more significant after treatment with mixtures of Fh and Fc containing 2%HPCD(Fc2)than that of other mixtures. In an orthotopic breast tumor model, compared with those of free CA4,or Fc with a fast or slow releaseof CA4, Fh/Fc mixtures with CA4 release durations from 2 to 12 days indicated a lower tumor growth rate, a prolonged animal survival, a lower vessel density in tumors, and a less significant tumor metastasis. It demonstrates the advantages of fiber fragment mixtures in independently modulating the release of multiple drugs and the essential role of release tuning of chemotherapeutic drugs and vascular disrupting agents in improving the therapeutic efficacy, reducing the side effect and improving the life quality of the patients.

**Keywords:** Cancer, Older people, Injectable fiber fragment , Antitumor efficacy, Life quality.

## Distinguishing the viability of a single yeast cell with an ultra-sensitive radio frequency sensor

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### Abstract

Sensing and identifying a single cell are essential for the operation of flow cytometers, which are basic tools for cell biology studies and clinical disease diagnostics. Single cell analysis is also important for screening cell-based drugs, differentiating cell states, and distinguishing cell responses to external stimuli and intracellular reactions. Therefore, many efforts have been devoted to developing single-cell sensing and analysis tools through different approaches, including optical analysis, chemical analysis, and nanomagnetic particle (labeling) approach. However, these techniques need labeling procedures, and they are incompatible with CMOS technologies, which provide a platform for low-cost, high-performance micro-total-analysis-system (mTAS) development. As a result, electronic, label-free cell sensing and analysis have attracted a lot of recent interests even though such a system has yet to be developed. Cell dielectric properties at higher frequencies, e.g. GHz radio frequencies (RF), have rendered themselves as a promising mechanism for individual cell sensing and analysis since it is generally recognized that heterogeneous cells have different RF dielectric characteristics and homogeneous cells have similar properties. These cell-specific RF properties include information of cell morphology, physiological state, and viability, dictated by different cell components, such as cell membrane, cytoplasm and organelles. High frequency probing signals are usually needed for their measurement since cell membranes and fluid medium would block lower frequency probing signals. Unfortunately, developing such RF sensors is very challenging since cell RF dielectric properties are usually close to that of medium fluids. The small cell sizes further diminish the attainable signal levels. Consequently, sensing and identification of a single cell with an RF sensor have not been demonstrated so far.

We propose and demonstrate a simple, ultra sensitive radio frequency (RF) sensor to detect a single yeast cell and distinguish its viability in a microfluidic channel. On-chip interference is used to cancel background probing signals to improve sensor sensitivity. Individual viable and nonviable yeast cells ( $\sim 5.83 \pm 0.85 \mu\text{m}$  in diameter) are measured with clear sensing and identification of these cells.

**Keywords:** Radio frequency sensor, Yeast cells, Permittivity, Microfluidic channel, On-chip interference.

## Tracking and Health Prediction Technology for Geracomium based on RFID

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### Abstract

The world will be full of the Internet of Things in the future. Radio Frequency Identification (RFID) is an important technology in the Internet of Things. It is used to automatically identify the target objects and apperceive everything in the world through radio frequency communication. Along with the people are ageing, the requirements of nursing and supporting the elderly are more urgent in geracomium, thus the health state of the elderly come to be the focus in geracomium for the managers and the families. To track and monitor the activities of the elderly daily and reflect their health, the technology of RFID can be applied. So the research for the tracking and monitoring by RFID is very significant. The RFID applications for the elderly will settle the safety for nursing and the health state for monitoring, and develop its applications in the Internet of Things. It is important for the construction of the smart city, wisdom awareness and information digitalization to study the authentication technology in RFID and its applications in tracking and monitoring areas.

Based on the idea of designing a tracking and monitoring RFID system, we apply the health status prediction of elderly people, and carries out study on authentication technology in RFID. Our main work and contributions are as follows:

- 1) A monitoring and tracking system based on RFID for geracomium is designed. This system is realized with the proper device type of RFID for monitoring and locating based on the idea of the Internet of Things. The structure, monitoring function and database of this system is elaborated clearly. So fast positioning, real-time monitoring and response, and timely nursing can be handled properly for the elderly, thus, the safety of elderly people in geracomium and the work efficiency of managers are well improved.
- 2) The health status prediction method based on RFID data source for elderly people is studied. As existing tracking and monitoring systems in geracomium cannot reflect the health status of the elderly from their daily routine, on the basis of medical research and the construction of analytic function for elderly health, some health index indicating the health condition of the elderly is analysed based on BP neural network, to predict the health status of the elderly and provide real-time and low-cost decision support for geracomium management.
- 3) A RFID security authentication protocol based on Hash function is designed. As existing authentication protocols have various defects, an improved RFID mutual authentication protocol based on Hash function is proposed. This protocol solves the non-synchronous problem in updating back-end data base and labels shared keys, reduces the exhaustive search and Hash calculation in back-end database by using label location index, which further improves the execution efficiency and scalability of RFID system, supports tag ownership transfer and is applicable for low-cost application environment with massive RFID tags.

**Keywords:** RFID, Tracking, Health prediction, Security authentication.

## Data Dissemination in Wireless Sensor Networks with Network Coding

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### Abstract

With the rapid development and widespread of information and communication technologies, more and more sensors and smart mobile devices are used in medical and health services for the elderly. The sensors could be used in health monitoring systems, such as the wearable devices used to collect the vital signs (e.g., body temperature, heart rate, etc.) or perform some operations (e.g., the smart insulin infusion pump). They also can be used in safety monitoring systems, such as the GPS sensors used to positioning the elderly and the Alzheimer's patients.

In those applications, the sensors and mobile devices are usually connected to a server via wireless networks. Sometimes, it is essential for the server to reliably disseminate large-size common files or messages to multiple sensors or mobile devices. For example, the service provider may want to update the software running on sensors remotely when bugs are found, or push rehabilitation training videos to a certain class of patients. However, the broadcast packets are not always successfully received by all receivers because of interference, path loss and fading. The traditional way to retransmit the lost packets is using Automatic Repeat-reQuest (ARQ). The retransmitted packets may not be useful to every user, and therefore the traditional ARQ is energy inefficient and time consuming. With the constantly increasing usage of sensors, it is would be a heavy burden for base stations to handle the tremendous number of sensors in such a simply way in the future as well. Besides, since the receivers, i.e. the sensors and intelligent mobile devices, usually are powered by batteries, it would be fatal for them to maintain such long lasting communications.

To address the aforementioned problems, linear network coding techniques, which have been proved to be an efficient way to improve bandwidth efficiency and reliability of a network, can be adopted to such broadcast scenarios. The network coded packets are linearly combined among the original packets and an encoding vector specifies the coefficients for the linear combination. An encoded packet together with a header which contains the corresponding encoding vector is broadcasted to all users. It is said to be *innovative to a user* if the corresponding encoding vector is not in the subspace spanned by the encoding vectors already received by that user. It is called *innovative* if it is innovative to all users who have not yet received enough packets for decoding. By broadcasting innovative packets to receivers, the broadcast efficiency can be improved. Considering the receivers are sensors and mobile devices, which in general do not have strong processing capabilities, a low decoding-complexity network coding algorithm is designed to select innovative coded packets. To reduce decoding complexity, the use of sparse linear network code is proposed, since the sparsity property of encoding vectors can be exploited when solving systems of linear equations. Generating a sparsest encoding vector with large finite field size, however, is shown to be NP-hard. An approximation algorithm that guarantee the Hamming weight of a generated encoding vector to be smaller than a certain factor of the optimal value is constructed.

In some applications, the wearable or implantable sensors can firstly connect to a sink central device that acts as a coordinator in a wireless body area network, and then connect to the server via the coordinator. The coordinator here can be treated as a relay node. To address the data dissemination problem in such scenarios, the proposed network coding algorithm is also extended to relay-aided cases. Both network coding and scheduling problems are considered. A deterministic network coding algorithm is designed to select innovative encoding vectors, which is applicable to both base station and relay node.

Simulation shows that the proposed network coding algorithm and scheduling schemes work very well on reducing completion time when compared to the traditional ARQ schemes.

**Keywords:** Data Dissemination, Network Coding, Low Decoding-Complexity.

## The influence of laser effects on laser induced damage and laser processing

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### Abstract

The main contents of this report consists of three parts: part one is laser effects, which include thermodynamic effect, ionizing effect and laser plasma effects. Laser plasma effects are multiple, which include inverse bremsstrahlung absorption effect, ionizing radiation effects and shock wave effect. Inverse bremsstrahlung absorption effect can make the deposit of laser pulses deposit energy, which can make the cut-off of energy transmission of laser pulse, while ionizing radiation effects mainly come from the shortwave part of the radiation spectrum. The shock wave of laser plasma has high pressure, which can make the fracture damage of target. Part two introduces the influence of laser effects on laser induced damage, to be specific, there is a significant differences in thermal effects and thermal stress effects, the former can cause the melting, vaporization and ablation of materials, while the latter can form crack defect. The ionization radiation effects, which include avalanche ionization and multiphoton ionization, can make the generation of laser plasma. The expansion of laser plasma with high temperature and pressure can cause the serious damage to target. The quality of laser processing is closely related to laser effects, that is, different laser effect can cause different processing characteristics, which will be introduced in part three, by using laser paint stripping and laser cleaning as examples. Our studies on laser paint stripping suggest that laser paint removal are dominated by the: chemical ablation effects, thermal stress effects and laser plasma effects, in which the thermal stress effects are most favored while laser plasma effects should be avoid during removal operations. Based on the thermodynamic equations, we numerically evaluated the spatial distribution of the temperature rise as well as thermal stress in the paint and substrate under the irradiation of laser pulse at 1064nm. The obtained curves of the paint thickness versus threshold influences can provide the reference standard of laser parameter selection in view of the paint layer with different thickness. Our investigations and the methods proposed here might give hints to the efficient operations on the paint removal and lowering the risk of substrate damages. The study on the conditions for Laser-Induced Plasma to Effectively Remove Nano-Particles on Silicon Surfaces found that: the particles are removed from silicon surface by means of irradiation and shock wave of laser plasma. The laser plasma shock wave plays a dominant role in removing particles, which is attributed to its strong burst force. The pressure of LPSW is determined by laser pulse energy and the gap between the focus position and substrate surface. In order to obtain the working conditions for particles removal, the removal mechanism particles, the temporal and spatial characteristics of velocity, propagation distance and pressure of shock wave have been researched. On the basis of the results above, the conditions for nano-particles removal are achieved.

**Keywords:** Laser effects, Laser induced damage, Laser processing, Laser plasma shock wave.



## A semi-automatic workflow of constructing printable 3D models for cerebrovascular surgical planning based on MR angiography and CT data

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### Abstract

The information of brain disease from neuroimaging techniques was traditionally displayed on films or screens, facilitating the diagnosis. However, this would be changed by the emerging technique called three dimensional (3D) printing. This technique deposit materials, such as plastic or metal, layer by layer to construct solid 3D models. It makes the disease information from a patient available “by touch”. Surgical treatment of complex cerebrovascular lesions, such as arteriovenous malformations (AVMs) and aneurysm, require careful planning before surgery. The 3D-printed models have the potential to help surgeons to rehearse the cases beforehand and reduce operative risk. Time-of-flight (TOF) MR angiography is a widely used sequence of evaluating cerebral arterial diseases. TOF MRA could provide high spatial resolution and good blood/tissue contrast without the need for the injection of contrast agent on modern clinical 3T scanner. Thus, image data from TOF MRA is a good source for constructing 3D printable cerebrovascular models. In some case, the surrounding skull anatomy is also needed to determine the operative approach. These information can be acquired from a routine CT scan. In this work, we describe a semi-automatic workflow that combine TOF-MRA data and CT data to construct a printable 3D model for cerebrovascular surgical planning.

A 57 years old male patient suspected to aneurysm was involved in this work. MRA data was acquired on a clinical 3T scanner with an 8-channel phase array head coil using 3D TOF sequence. CT scan was performed on 128 detectors CT scanner (80kV, 358-410mA, 1mm slice thickness). High resolution T1 weighted anatomical images were also acquired for registration purpose using MP-RAGE sequence. Both MRA and CT data were co-registered to T1w image to unify the resolution and imaging space using affine registration tool of Advanced Normalization Tools (ANTs). The signal inhomogeneity of MRA data was corrected using N4BiasFieldCorrection tool from ANTs package before registration. The segmentation of vessel and skull were performed using 3D level set algorithm implemented in ITK-SNAP software. Mathematic morphological processing was then used on the raw segmentation to fill the cavity inside the skull and remove unconnected parts. The segmented binary images of vessel and skull were converted to mesh data and export to STL format. We further use the ZRemesher function from ZBruash software (Pixologic inc.) to generate high quality topology as well as removing unnecessary polygons.

In this work, we proposed a semi-automatic workflow of constructing printable vessels and skull models of an individual patient based on MRA and CT images. The full construction can be done within one hour with minimal manual intervention. The only two steps need manual operation is to place initial seeds at main branch of vessels for level set evolution and to draw guide lines for mesh refinement. The constructed models were consistent with the findings of MRA in our case, a 4mm aneurysm at M1 section of right middle cerebral artery. Surgeons can physically hold the 3D models, view them from different angles, practice the operation with real instruments and get tactile feedback, especially for deep vessels that are very tricky to operate on. The 3D printed models may be even more meaningful for surgical planning of interventional therapy or medical education.

In conclusion, our proposed workflow may improve the feasibility of using 3D printing technique in the treatment of intracranial artery diseases. Further investigations are warranted to optimize this technique and translate it into research and clinical practice.

**Keywords:** 3D printing, MR angiography, CT, Image segmentation.

## Multiresolution convex variational model for multiphase image segmentation

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### Abstract

We investigate a convex variational model for multiphase image segmentation by incorporating a multiresolution approach. The variational model by extending the multiphase level set method is an energy functional approach whose accurate boundaries and robust response to image variations, yields a global solution by minimizing the multiphase segmentation energy constrained with some constraint conditions. At first, by incorporating edge-based information, a nonconvex energy functional is introduced on the membership functions, which are used as indicators of different homogeneous regions. Then, the nonconvex problem is converted into a continuous convex formulation. Finally, a dual minimization formulation of the binary partitioning function model accurately describes disjoint regions using stable segmentations by avoiding local minima solutions and ambiguous segmentation. Experiments results show the proposed model is robust to noise, and independent of initialization and unambiguous segmentation. When compared with the traditional level set based implementations, the proposed model can get more accurate results and higher computational efficiency.

**Keywords:** Image segmentation; Convex formulation; Global minimization; Variational model.

## A Jointly Optimized Predictive-Adaptive Partitioned Block Transform for Video Coding

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### Abstract

In this paper, we propose a jointly optimized predictive-adaptive partitioned block transform to exploit the spatial characteristics of intra residuals and improve video coding performance. Under the assumptions of traditional Markov representations, the asymmetric discrete sine transform (ADST) can be combined with a discrete cosine transform (DCT) for video coding. In comparison, the interpolative Markov representation has a lower mean-square error for images or regions that have relatively high contrast, and is insensitive to changes in image statistics. Hence, we derive an even discrete sine transform (EDST) from the interpolative Markov model, and use a coding scheme to switch between EDST and DCT, depending on the prediction direction and boundary information. To obtain an implementation independent of multipliers, we also propose an orthogonal 4-point integer EDST, which consists solely of adds and bit-shifts. We implement our hybrid transform coding scheme within the H.264/AVC intra-mode framework. Experimental results show that the proposed scheme significantly outperforms standard DCT and ADST. It also greatly reduces the blocking artifacts typically observed around block edges, because the new transform is more adaptable to the characteristics of intra-prediction residuals.

**Keywords:** Even discrete sine transform (EDST), Interpolative Markov representation, Intra-prediction residuals, Blocking artifact.

## Fast diffraction calculation on outside-in propagation model of cylindrical computer generated holograms

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### Abstract

Diffraction calculation is a time consuming yet, critical step in computational optics, and has found numerous applications in laser hologram, optical wavefront detection, optical encryption, and so on. Most of these applications are based on the computation of diffraction distributions between two parallel flat surfaces using scalar diffraction theory such as Kirchhoff formula, Rayleigh-Sommerfield formula, diffraction's angular spectrum transmission formula, or others. In recent years, with the availability of fast Fourier transform (FFT) algorithm and high performance computing platforms, many applications based on computation of diffraction distributions between non-planar surfaces have also been reported.

A potential application of non-planar diffraction is 360° computer-generated hologram. In this application, the shape of the observation surface is usually cylindrical. If the object surface is also a concentric cylindrical surface, the diffracted wavefront on the observation surface then may be expressed in the form of a convolution with the distribution on the object surface. The FFT algorithm then may be applied to accelerate the convolution computation by orders of magnitude. A fast calculation method was proposed for cylindrical computer-generated holograms (CGH) by using the convolution and FFT. Further, a faster calculation method was proposed for cylindrical CGH based on wave propagation in spectral domain. In another research, the previous proposed method was used for the simulated reconstruction of a 3D object in 360° from cylindrical hologram. More recently, an algorithm of wavefront recording surface for fast calculation of cylindrical CGH was proposed. These existing works compute the diffraction distribution between a pair of concentric cylindrical surfaces using an inside-out propagation (IOP) model where the object surface is the inner cylinder and the observation surface is the outer cylinder. Due to the limited observation or hologram surface area, the sizes and resolutions of objects on the object surface may be limited. In the addition, the IOP model also needs to calculate the diffraction distribution, which is propagated from outside to inside cylindrical surface, in the reconstruction process.

In our previous research, the opposite propagation direction in an outside-in propagation (OIP) model, where the object surface is the outer cylinder and observation surface is the inner cylinder, was considered, and the corresponding formula of diffraction calculation was derived for the OIP model. To the best of our knowledge, no other prior work on the diffraction distribution computation of the OIP model has been reported. In this paper, a fast method based on the convolution theorem using FFT algorithm, which is hereinafter referred as convolution method, is proposed to accelerate the diffraction calculation of OIP model. Then the well-sampling conditions of the proposed convolution method are analyzed. The experiment of generating and reconstructing a cylindrical hologram for a cylindrical object is also carried out successfully.

**Keywords:** Diffraction theory; Computer Generated Hologram; Cylindrical CHG; Holographic display.

## Integral imaging 3D display with comfortable visual effect

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### Abstract

In recent years, multi-view three-dimensional (3D) display has been spreading rapidly because of its simple structure and good 3D effect. But the visual fatigue caused by the inconsistency between the convergence and accommodation is the main problem that hinders the development of multi-view 3D display. Integral imaging (II) 3D display which bases on the theory of the reversibility of optical path has no visual fatigue problem. It was reported that 73% of subjects keep eyes on the real integrated 3D image instead of the display panel in the near viewing distance of II and the conflict between the convergence and the accommodation is relieved in the super multi-viewing region of II. We analyzed the accommodation and convergence distances when viewing the 3D images reconstructed by the II 3D display, and found that the convergence point is always in the range of accommodation for the 3D image in a suitable depth range, which means that the accommodation and convergence distances are coincident. In the experiment, subjective and objective tests were carried out to compare the visual comfort between II and multi-view 3D displays. In the subjective evaluation test, 82.4% observers feel more comfortable when viewing II 3D picture. In the objective test, we test the change of observers' fusion range. 88.2% observers have better fusion ranges after viewing II 3D picture than multi-view 3D picture. So we can see that II 3D display has better visual comfort and is suitable for older people.

Augmented reality (AR) display allows the overlaying of virtual two-dimensional (2D) or 3D images on viewer's real world view so that the virtual 2D or 3D images seamlessly blend into the real-world scene. II is a good candidate for AR display, since it provides full parallax 3D images with quasi-continuous viewpoint, and supplies various physiological depth cues so that viewers can freely change the accommodation and convergence between the virtual 3D images and the real-world scene without feeling any visual discomfort. We proposed a magnified AR 3D display based on II with high geometric fidelity. The display system includes a micro II display unit, a convex lens and a half-mirror. The micro II display unit contains a micro elemental image array and a micro-lens array, and creates a micro 3D image. The micro II display unit locates within the focal length of the convex lens, so that the micro 3D image is magnified by the convex lens. The rays from the magnified 3D image are reflected into the viewer's eye by the half-mirror while the rays from the real-world scene are transmitted through the half-mirror. So the magnified 3D image overlaps with the real-world scene in viewer's eyes, and the AR 3D feature is achieved. The proposed system can be integrated to the presbyopia glasses so that older people can have a 3D video call with their children even when they are cooking or fishing and without feeling any visual discomfort.

**Keywords:** 3D display, Integral imaging, Visual comfort, Augmented reality.

## Zoom microscope objective using electrowetting lenses

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### Abstract

We report a zoom microscope objective which can achieve continuous zoom change and correct the aberrations dynamically. The objective consists of three electrowetting liquid lenses and two glass lenses. The magnification is changed by applying voltages on the three electrowetting lenses. Besides, the three electrowetting liquid lenses can play a role to correct the aberrations. A digital microscope based on the proposed objective is demonstrated. We analyzed the properties of the proposed objective. In contrast to the conventional objectives, the proposed objective can be tuned from  $\sim 7.8\times$  to  $\sim 13.2\times$  continuously. Using such an objective, the fabrication tolerance of the optical system is larger than that of a conventional system, which can decrease the fabrication cost. The proposed zoom microscope objective can not only take place of the conventional objective, but also has potential application in the 3D microscopy.



## Region of interest detection and video coding based on machine learning

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### Abstract

Multi-Video Coding (MVD) plus depth are adopted in current 3D video coding. Supposing that the 3D video is applied into the network, the huge data and high complexity are tough challenges. In order to accelerate the step of the 3D video networking, the following several issues will be studied, according to the characteristic smooth region and sharp edge in depth map, under the plat of 3D-HEVC. (1) Based on the distribution characteristic, Depth Modelling Mode (DMM) mode decision and sharp edge filtering is studied to propose the filtering algorithm for the DMM mode in up/down sampling coding, which will improve the coding efficiency. (2) The quantitative relationship between quantization step of the depth map in down sampling coding and that in normal coding will be studied to propose the rate-distortion optimization for up/down sampling. (3) The relationship between the depth distribution characteristic and the nonlinear transformation angularity is studied to propose nonlinear depth representation algorithm, which will improve the quality of the visual view synthesis. (4) The estimating algorithm of the rate-distortion cost of the DMM mode coding by the depth distribution characteristic is studied to propose the condition that the rate-distortion cost computation for the depth CU layer can be skipped, which will reduce the coding complexity.

In order to accelerate the step of the 3D video networking, the following several issues will be studied, according to the relationship between the features of motion and depth in 3D videos and the human interest, under the plat of 3D-HEVC. (1) The interesting degree of various depth distances of objects and depth hops to human eyes will be studied to propose a method of characterization and detection for nonlinear depth hop degree. (2) The building of training characteristics of motion and depth and the compulsive mode decision according to the existing region of interest (ROI) will be studied to propose an acquisition method of the decision ranges of the relative motion strength and depth hop degree based on machine learning. (3) The quantitative relationship between the hop degrees of the motion and depth and the QP distance in motive and still ROIs will be studied respectively to propose a decision method of the interesting degree based on the hop degrees of the motion and the depth. (4) The conditions when the rate-distortion cost is optimal under the various hop degrees of the motion and depth will be studied to propose an adjustment method of Lagrangian factor in rate-distortion optimization based on the hop degrees of the motion and the depth. The research on the above science issues will not only provide some extensional scheme selection for the development of the international 3D video coding standard, but also provide some technology reference for that in our china.

**Keywords:** Example, Video coding, Three-dimensional, Multi-view, Depth image, Motion estimation, Newton Fund.

## Scalable Lightweight Video Coding for Visual Remote Wireless Patient Monitoring

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### Abstract

Tight budgets and emergency room overcrowding will contribute to the uptick in remote and wireless patient monitoring systems to track vital signs. Big progress has been made in last decade for in remote patient monitoring for "Zero distance" monitoring the condition and activity of the patients without the location limit, such as remote blood pressure monitors and glucose meters, remote real-time audio and video monitors, etc.. However, among all kind of data transmission in remote patient monitoring, the coding and transmission of video data is challenging, especially at the circumstance that the patient is not just staying at home and the wearable device is needed for video transmission. Although the exiting development in mobile communication has made the wireless video communication more applicable. The problems of how to make the video encoder more "light" in power consumption, more robust to transmission error in wireless channel and more flexible for heterogeneous mobile network are still not settled.

In this work, we propose a Scalable Distributed Video Coding (SDVC) more applicable to remote patient monitoring, which, together with the advantageous DVC framework and scalable video coding framework, helps to realize low power consumption, low complexity, high compression efficiency and strong error-resistance, and accommodate dynamic networks or limited bandwidth. The SDVC proposed in this work is mainly aimed at video quality scalability for both WZ frame and KEY frames. Two different scalable coding schemes are designed for KEY frames and WZ frames respectively.

The SDVC achieves scalable by coding different DWT coefficients. For the scalability of WZ frame, we make use of the different bit rates obtained by encoding the different sub-bands of DWT to obtain the Base Layer (BL) and two Enhancement Layers (EL<sub>1</sub>, EL<sub>2</sub>). More specifically, we set the LL<sub>3</sub> of wavelet coefficients as the BL layer, HH<sub>j</sub>, ( $j \in 1, 2, 3$ ) as the EL<sub>1</sub> layer, LH<sub>j</sub>, ( $j \in 1, 2, 3$ ) as the EL<sub>2</sub> layer, and HL<sub>j</sub>, ( $j \in 1, 2, 3$ ) as the EL<sub>3</sub> layer. For the scalability of KEY frames, we get wavelet coefficients of the residuals information between the current frame and the reconstructed frame, and set the LL<sub>3</sub> and HH<sub>j</sub>, ( $j \in 1, 2, 3$ ) as the, LH<sub>j</sub>, ( $j \in 1, 2, 3$ ) as the layer, and HL<sub>j</sub>, ( $j \in 1, 2, 3$ ) as the layer. In order to achieve better coding efficiency, a Successive Side Information Refining (SSIR) scheme is proposed. In the proposed SSIR scheme, the motion field is refined upon the decoding of received layer, then the side information is refined by motion compensated refinement. As a results, the more layers the decoder received and decoded, the better quality of the reconstructed frames will have. Experimental results have shown that the quality scalabilities have been achieved for both the WZ frame and the KEY frames. The proposed work can be applied in the field of welfare, particularly, to remotely monitor patients and can also provide remote nursing care for the elderly who lives alone.

**Keywords:** Remote Patient Monitoring, Distributed Video Coding, Wavelet Domain, Power Consumption.

## Employing Video Coding Combined with Super-resolution Reconstruction Technology for the Health of Older People

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### Abstract

With the increasing aging population problems, how to ensure the health of these populations is a serious challenge. Video communication is very important in many application scenarios for older people, such as video surveillance indoor or outdoor.

Currently the resolution of video is becoming larger, which brings great challenges to both the bandwidth and the storage capacity of the devices. So it is important to reduce the bitrate of the image or video and maintain the quality at the same time under the premise of limited bandwidth. With the completion and application of HEVC, the hybrid coding mode based on block has been developed to a new level, so how to improve the performance of video coding based on HEVC is a worthy research field. In order to reach the goal of improving the performance of video coding for HEVC, in our earlier research, the super resolution reconstruction technology is combined with the HEVC coding framework, and two solutions are proposed as described below.

In the first solution, the main idea is that the single image super-resolution reconstruction is integrated into HEVC. At the encoding side, low resolution video is obtained after the down-sampling of the original video, after that the low resolution video is put into HEVC encoder to generate the corresponding video stream; at the decoding side, the low resolution video streams is obtained and decoded, and the corresponding low resolution video is generated, then the low-resolution video is reconstructed to the same size as the original video through super-resolution reconstruction operation, which is based on sparse representation.

In the second solution, the idea of key frame and non-key frame is introduced to the HEVC combined with super-resolution reconstruction technology. In this solution, the key frame and non-key frame are selected at the encoding side. The key frame is put into the HEVC to encode without down-sampling operation; the non-key frame is down-sampled before put into the HEVC to encode. At the decoding side, the video stream is received and decoded to get the key frame and the non-key frame, the key frame is used to train an ultra-complete dictionary, which is adopted to guide the reconstruction of the non-key frame.

Experimental results show that the proposed two solutions have a better rate distortion performance to HEVC at low bitrate segments.

This work was supported by the National Natural Science Foundation Project under Grant 61471248.

**Keywords:** HEVC, Super-resolution Reconstruction, Video Compression, Sparse Representation, Key Frame.

## Research on Video Subtle Motion Magnification

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### Abstract

With the development of healthcare, there is a need to monitor a patient's physiological video signals by a remote, non-contact means. However, the human visual system has limited spatio-temporal sensitivity, and many informative physiological signals that fall below this capacity can't be seen. If these subtle variable signals can be amplified enough to be observed by naked eyes, it will be very meaningful for remote medical treatment. Thus, it's necessary to study the magnification of biological subtle motion.

Motion magnification can redisplay a subtle motion signal in an exaggerated way, and this is helpful to observe and analyze signal features. For example, human skin colour varies slightly with blood circulation and this variation is hard or impossible for human to see, but it can be magnified to reveal interesting mechanical behaviour and exploited to extract pulse rate.

By recording a video of the motion region, the pixel value of certain position changes along with fluctuations in motion. Temporal processing has been used previously to extract invisible signals. The method of Lagrangian approach, works well to enhance motions of fine point features and support larger amplification factors, while it is more sensitive to increases in spatial noise. The method of Eulerian Video Magnification combines spatial and temporal processing of videos to amplify subtle variations with good balance between performance and efficiency.

In our study, we present a 3D wavelet's methodology for subtle motion magnification, which not only improves performance of results, but also enhances efficiency of motion magnification. Our analysis is based on spatial and temporal projection of decomposition of the viewpoint video using the 3D wavelet transform. The video, which includes subtle motion, is firstly decomposed into different frequency bands, and by analyzing the features of different bands the optimal wavelet level is obtained. The video based on optimal level is processed by 3D wavelet temporal projection, by employing threshold function, and the interested video regions are selected. Then, these interested pixels are amplified by a given factor, added back to the original signal to generate the output video. The choice of threshold function and amplification factors can be tuned to support different applications. The characteristics of our algorithm lie in the following two aspects:

- Decomposing and reconstructing the video by using optimal level of wavelet transform instead of Gaussian pyramid.
- Finding the interested video region by using the threshold function of combining integral energy and maximum values of pixels.

We describe our algorithm and demonstrate how it can compute heart rate measurements from video images of the human face recorded using a simple webcam. The obtained results show that the level and threshold function we choose have a good effect for motion magnification.

We propose straightforward method that takes a video as input and exaggerates subtle changes by using wavelet decomposition and reconstruction. This method, which combines spatial and temporal processing, successfully reveals informative signals and amplifies small motions in real-world videos. The magnification performance is improved compared with traditional methods.

**Keywords:** Motion Magnification, Eulerian Video Magnification, Wavelet Transform, Spatial and Temporal Projection, Threshold Function, Optimal level.

## Smart Surveillance Video Analysis and Its Applications

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### Abstract

With the aging society, living and transportation of the elderly are getting more and more attention. However, lack of human resources is a big problem. Thanks to the rapid development of communication technology and computer vision, surveillance system based on behavior recognition techniques becomes a viable solution. The surveillance system can automatically analyze the behavior of the elderly in different scenes, and send alerts when something abnormal happens. Thus it can be seen that the smart surveillance system has a very important meaning to the health and safety of the elderly.

Due to specific situations in home surveillance system and public places in the city, we can divide our research into two parts: the individual and the group, and then we combine the two together. In this report, we will present our work on behavior analysis, abnormal detection and classification of early warning. There are four main parts of the report:

1. Brief description of behavior analysis. Behavior analysis and recognition of moving objects have great prospects and potential economic value, which can be widely applied in intelligent surveillance, sporting and military.
2. Our individual behavior recognition algorithms. Our action recognition framework consists of three components: feature extraction, dimensionality reduction, and classification. We propose a new dimensionality reduction method called compressive sensing with Gaussian mixture random matrix (CS-GMRM), in which a novel measurement matrix using Gaussian mixture distribution is constructed and is shown to satisfy the restricted isometry property (RIP).
3. Group movement pattern analysis and group abnormal detection. We study collective motion by measuring crowd collectiveness. To this aim, we propose novel collectiveness calculation approaches of crowd motion from kinetics and dynamics perspectives, and present algorithms for their applications to a variety of crowd analysis problems. And we combine a streakline model based on fluid dynamics with an abnormal behavior detection method presented by Hassner, and propose a modified algorithm to improve the recognition accuracy of abnormal crowd behavior.
4. Ongoing work and research plans. In the future work, we will further carry out the research work of behavior analysis system and anomaly detection, and we will study how to effectively apply the implemented algorithms to specific situations in home surveillance system and public places in the city.

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**Keywords:** Smart Surveillance, Action Recognition, Behavior Analysis, Abnormal Detection.



## The Study of Lumbar Strain Analysis Based on a 3-D Finite Element Model

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### Abstract

Lumbar disc herniation (LDH) is one of the common diseases in the elderly. Due to the parts of the lumbar intervertebral disc (especially nucleus pulposus) have a different degree of degenerative changes, spinal nerve root is compressed by herniated nucleus pulposus. The main clinical symptoms are lumbar pain and lower limb numbness, etc. As one of the main therapeutic methods for LDH, Caiqiao manipulation is an important branch of Tuina science (a form of Chinese manipulative therapy). It means that using their own gravity, chiropractors step on patients' waists and backs with feet rhythmically, reducing or alleviating the compression on the spinal nerve root. There exists a certain blindness in clinical practice, due to most chiropractors often choose mechanical parameters of the Caiqiao manipulation (position, orientation, magnitude, frequency, duration, etc) according to their own experience. With the development of science and technology, it is of great significance to research the mechanical parameters using scientific and technological means. Using MRI processing method, our research group constructs and validates a 3-D finite element model (FEM) of the human lumbar. Then we conduct Caiqiao simulation experiments, observe the effect of varying Caiqiao frequencies on the FEM, and do further research on mechanical parameters of the Caiqiao manipulation.

Firstly, we construct the 3-D FEM by segmenting MRI images, reconstructing and optimizing a 3-D geometric model, running surface fitting to form a 3-D solid model and generating tetrahedral mesh. In order to validate the obtained model, we compare the strain of the FEM with the experimental biomechanics data and the clinical data respectively under the same conditions. Through model analysis, we obtain the natural frequency range of the whole lumbar spine. Based on the natural frequency range and the clinical operation rules of the Caiqiao manipulation, combining with pressure waveforms and spectrum we previously obtained, we simulate 10 group conditions with different frequencies (0.4Hz, 0.8Hz, 1.2Hz, 1.6Hz, 2.0Hz, 2.4Hz, 3.0Hz, 3.4Hz, 3.6Hz and 4.0Hz) and observe the whole lumbar disc displacement and lumbar curvature changes under each frequency. According to the analysis of our partner (experts in University of Chengdu Chinese Medicine), the lumbar disc displacement and the lumbar curvature are maximal at a frequency of 2.4Hz. Under this condition, the compression on the spinal nerve root can be alleviated effectively. At the same time, the frequency of 2.4Hz is consistent with the method of Caiqiao expert Professor Luo.

The experiment shows that it is feasible to research mechanical parameters of Caiqiao manipulation based on the 3-D FEM and the mechanical parameters can be optimized by computer modelling, which can provide objective basis for clinical Caiqiao Experiment.

**Keywords:** MRI, Finite element model, Caiqiao manipulation, Lumbar disc herniation, Mechanical parameters.