A Study on Implementing Physiology-Based Approach and Optical Flow Algorithm to Thermal Screening System for Flu Detection

Norulzahrah M. Zainudin, Suzaimah Ramli, Kamarul H. Ghazali, M. Lazim Talib, and Nor Asiakin Hasbullah

***Abstract*—Viral outbreaks such as SARS, H5N1, and H1N1 have led the need of temperature monitoring in areas where crowds are expected such as in hospitals and airports. Infrared (IR) thermal screening, hitherto, has been found as powerful, quick and non-invasive method to detect the elevated temperature of febrile individuals when the temperature of the face is above 36°. Past research has proved that the most excellent area that represents the core body temperature is the medial canthal areas of the face as it is less dependent on the effects of ambient temperature. In realistic situation, the moving subjects are random and the angles of the skin surface and distances change dynamically and misdetection of canthal area could also be due to any other unwanted objects that have the same temperature. The normal approach is to ask a single person to stand still for 2 seconds to capture the temperature. However this approach is ineffective and this will lead to long queue in public. To solve this issue, we have proposed a combination of physiology-based and optical flow algorithm to extract vascular network from the face. The thermal camera is provided with colour and audible alarming, hence when the camera detect an abnormal temperature from a person, automatic febrile individual tracking alarm will report to the operator the current location of the individual.**

***Index Terms*—Infrared, optical flow algorithm, physiology-based approach, thermal image processing.**

I. Introduction

Every so often, there is a major change in the virus and it could spread rapidly around the world causing a high number of deaths. For instance, Influenza A H1N1 2009 that first appeared in Mexico, followed by a growing number of cases around the world, including Malaysia that had caused the World Health Organization declared a pandemic in June 2009.

Currently, the process of screening in public area for detecting high fever during pandemic is through face-to-face screening that required visitors that coming into the country to stand still at least 2 seconds for temperature capture. However this approach is ineffective and this will lead to long queue [1]. In addition, some people find this method of screening is invasive and uncomfortable.

Therefore, based on the impracticality, we have carried out a study to develop a direct crowd thermal screening system for flu detection using new technique of moving body temperature measurement based on physiology-based approach and optical flow algorithm. The medial canthal areas of the face will be the temperature detection area as it is less dependent on the effects of ambient temperature. A non-contact temperature measurement using thermal camera integrate with the programme that is combination of the physiology-based approach and optical flow algorithm which will be developed in the later stage so that it can automatically screen high temperature without the necessity of manually operated by human and having to check on each person.

II. Related Work

Flu-like pandemics such as bird flu(H5N1) and swine flu (H1N1) has caused illness, deaths and loss to people worldwide. In Jan. 2007, bird flu (H5N1) has killed at least 161 people worldwide and millions of birds of U.S $10 and $15 billion losses in poultry industry have been destroyed. Recently, WHO has reported that 636 cases of the latest pandemic disease, Middle East respiratory syndrome coronavirus (MERS-CoV) have been confirmed including 193 deaths [2].

This kind of pandemic causes fever has led the need of temperature monitoring in areas where crowds are expected such as in airports, hospitals and border-crossing points. Infrared thermal screening has been found as a powerful, quick and non-invasive method to detect the elevated temperature of febrile individuals [3]-[8]. Thus, a continuous pandemic response planning is crucially needed in order to reduce the importation of transmissible infectious diseases.

Thermal Imaging is a process of transforming imperceptible infrared radiation to visible image. Every object in the universe emits infra-red radiation as long as the object is above absolute zero (-273 ℃). The temperature of an object governs the amount of infra-red radiation emitted. Using thermal imager, a pictorial representation is produced to represent the detected heat without visible light content [9]. Febrile individual is detected through elevated body temperature, where the temperature of the face is above 38^{o}C. Past research has proved that the most excellent area that best represent the core body temperature is the medial canthal

Manuscript received May 15, 2014; revised June 30, 2014. This work was supported in part by the Education Ministry of Malaysia under Grant RAGS/2012/UPNM/SG05/6.

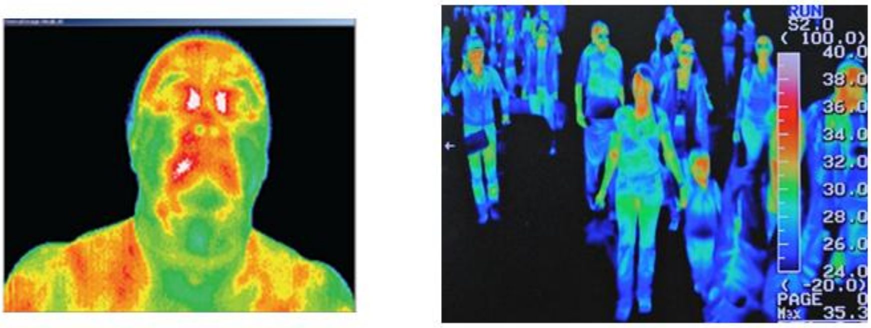
N. M. Zainudin, S. Ramli, M. L. Talib, and N. A. Hasbullah are with the National Defence University of Malaysia, Kem Sg. Besi, 57000 Kuala Lumpur, Malaysia (e-mail: norulzahrah@upnm.edu.my, suzaimah@upnm.edu.my, lazim@upnm.edu.my, asiakin@upnm.edu.my).

Kamarul H. Ghazali is with the Universiti Malaysia Pahang, 26300 Kuantan, Pahang, Malaysia (e-mail: kamarulhawari@gmail.com).

DOI: 10.7763/IJIEE.2015.V5.496

areas of the face as it is less dependent on the effects of ambient temperature as shown in Fig. 1(a) and Fig. 1(b) [10].

In realistic situation, the moving subjects are random and the angles of the skin surface and distances change dynamically. As thermography is really depending on the temperature, misdetection of canthal area could also be due to any other unwanted objects that have the same temperature. The normal technical advice is the need for the person to stand still at least 2 seconds for temperature capture as shown in Fig. 2. However this approach is ineffective and this will lead to long queue [1]. Therefore, an intelligent thermal screening system using the combination of physiological-based and optical flow methods is proposed.



(a) (b)

Fig. 1.(a) The medial canthal, corner of the eyes where the lachmarl(tear) duct comes to the surface. The red colour shows the hottest region of the face. (b) The thermal screening of the crowd with dynamic face angles and distances from the camera.

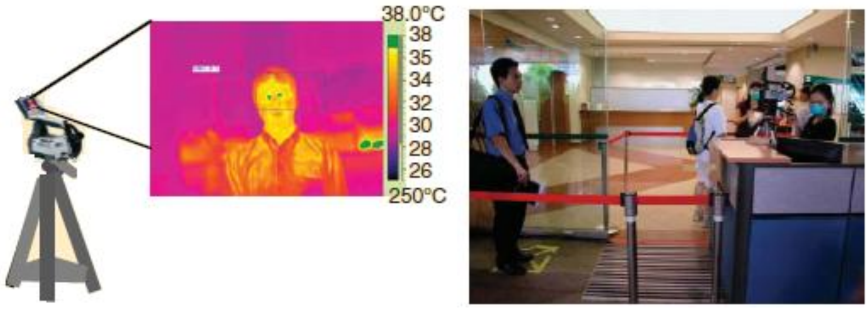
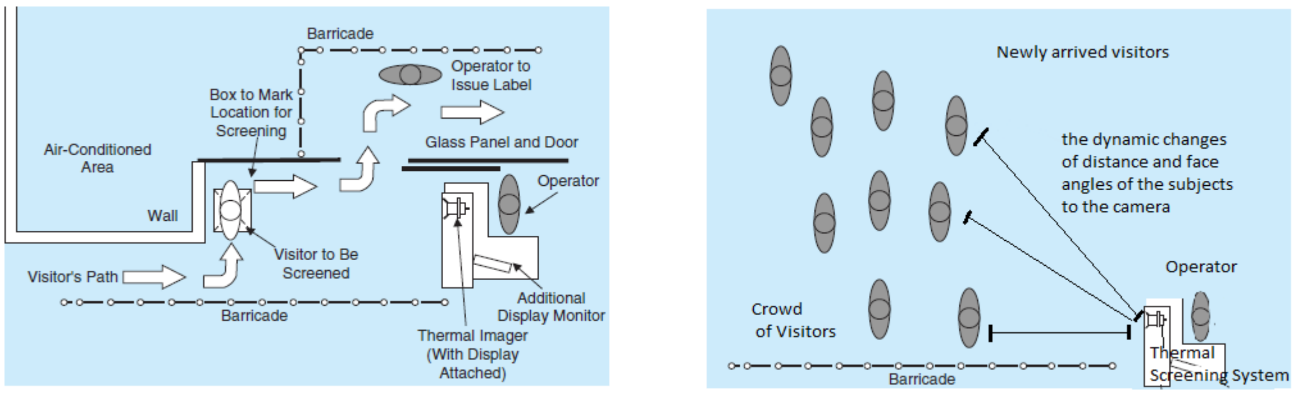


Fig. 2. Shows the actual setup at the entrance of a hospital (courtesy Dr. G Kaw, TTSH, Singapore).



(a) (b)

Fig. 3. The schematic plan view layout of (a) typical imager setup (courtesy of Dr. G. Kaw TTSH, Singapore) (b) The proposed screening system for dynamic changes of distances and face angles of the subjects that eliminate long queues.

This does not require a person to comply the standard framing and positioning protocols for a region of interest of the anterior view of the head [1].

Fig. 3(a) shows the typical thermal imaging setup at airport where the person is advised to at least stand still for 2 seconds for the camera to capture the image, where this method will cause long queues and increase the probability the transmission of contagious fever [1]. Fig. 3(b) shows the system proposed in this research that has high ability to overcome the dynamic angles of faces and distances.

One of the most important problems in this temperature detection system is getting the right decision. The technique used to detect the temperature at moving object usually gives low results. Detection system automatically detects the temperature in the crowd where there is no existing system used to detect the temperature manually. This study proposes the development of automatic systems which incorporate techniques face detection and tracking of objects are suggested. Detection of temperature on moving objects is done by detecting the object. Face area of focus for measuring the temperature of an object is detected when the detection is finished.

III. Materials and Methods

A. Physiology-Based Approach

Physiology-based approach is a technique that used the physiological information on the face. In physiology, human faces rich of "hot" and "cold" tissues corresponds to vasculature that could be modeled as mixture of two normal distributions as shown in Fig. 4 [8]. From the information, we could extract between facial and background, facial and unwanted hot objects. This is the important step as once the correct region of interest obtained; medial canthal temperature could be extracted as it is normally the highest temperature on the face.

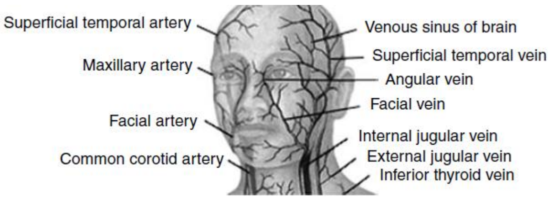


Fig. 4. Superficial blood vessels on the face.

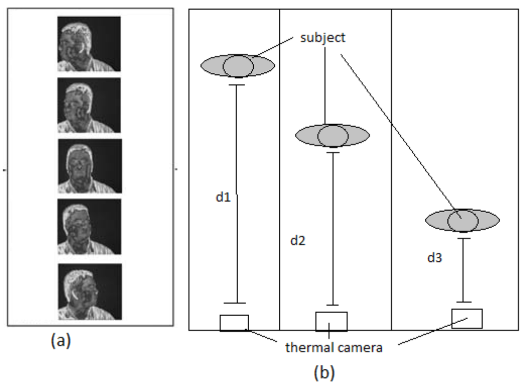


Fig. 5. (a) Five differents poses at different angles (b) the different distances of d1, d2, and d3 of the subject to the camera.

Physiology-based face recognition in the thermal spectrum has been used for biometric application but this method is still new to track the moving febrile individuals. The research carried by [8] only extracts the vascular network of human faces at fixed distance. In this research the combination of different pose angles at different distances from the camera as shown in Fig. 5 is proposed to extract the medial canthal area of human face and later collect the temperature information for flu detection.

B. Optical Flow Algorithm

Optical Flow-based approach using Horn-Schunck(HS) method is also suggested in motion detection as this method can detect minor motion of objects and could provide 100% flow field [4]. In the free-flow subjects, the optical flow could be used to track the region of interest (medial canthal area) and track the current location of the febrile individuals. This later useful for automatic febrile individual tracking alarm that will report to the operator the current location of the individual and the total febrile persons found at one time.

C. Adaptive Network-Based Fuzzy Interference System (ANFIS)

Thermography pre-processing alone may not sufficient without the analytical tools. Ng et al have successfully improved the fever identification performance using the advanced Integrated Technique of Parabolic Regression, Radial Basis Function Network (ANN RBFN) and Receiving Operating Characteristics (ROC) from the biostatistical method at 96% accuracy rate, 95% sensitivity, and 85.6% specificity. The result was better than using the biostatistical method which showed 93% accuracy, 85.4% sensitivity and 95% specificity. The algorithm proposed in this research is the Adaptive Network-Based Fuzzy Interference Systems that combines the merits of fuzzy systems and neural network (NNs). This is assumed to produce more powerful tool for modeling [11].

D. Image Classification Pre-Process

In this section, the thermal image will be classified to discriminate those images between low and high human body temperature. As shown in Fig.6, an image will be acquired using thermal camera that will be processed that involves colour-based segmentation using the L*a*b colour space for selecting the region of interest. Next, a feature will be extracted using Optical Flow Algorithm as well as Physical-based Approach. Those results then will be classified in order to discriminate the image between low and high human body tempersature value.

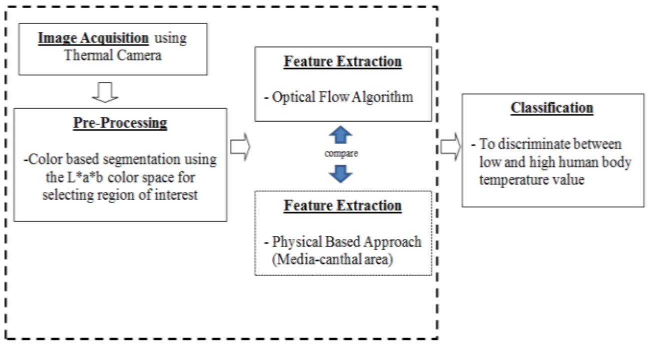
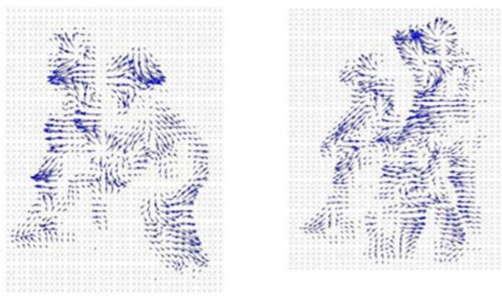


Fig. 6. Thermal image feature extraction method.



(a) (b)

Fig. 7. Optical flow result.

IV. Results and Discussions

In this section, the results are presented based on thermal images of moving subjects in the airport at the same angle. The frame rate is 160fps, and only 15 frames are used for the training data. The algorithm was implemented using the Matlab version 7.1. We have implemented physiology-based approach and optical flow algorithm in this experiment. Fig. 7 is the results of experiment that has been carried out using the optical flow algorithm. The result shows that there is discriminant value of the body temperature where the magnitudes of the feature in Fig. 7(a) is consistent that indicates the body temperature is normal. In contrast, Fig. 7(b) shows that the magnitudes are uneven which specifies that the body temperature is high.

V. Conclusion

This paper explains a study on implementing Physiology-based Approach and Optical Flow Algorithm to Thermal Screening System for Flu Detection. This paper has described all elements that are required in implementing the system. The future work will be implementation and integration of the whole experiment findings as a research product (a smart crowd thermal screening for flu detection) that is socially beneficiable, especially to reduce the importation of transmissible infectious diseases applied in public areas such airports and hospitals.

Acknowledgment

The first of author would like to thank Research Management Office and Faculty of Defence Science and Technology, National Defence University Malaysia for the support and aid during the making of this paper.

References

[1] B. Ronald, F. Daniel, and P. Leando, "Protocol for rapid point-of-contact public screening for SARS using clinical digital infrared thermal imaging," *American College of Clinical Thermology (ACCT)*, 2003.

[2] WHO. (2014). Global Alert and Response (GAR). [Online]. Available: http://www.who.int/csr/don/2014_05_28_mers/en/

[3] L. S. Chan, G. T. Y. Cheung, I. J. Lauder, and C. R. Kumana, "Screening for fever by remote sensing infrared thermographic camera," *J. Travel Med.*, vol. 11, pp. 273–278, 2004.

[4] A. D. Hay, T. J. Peters, A. Wilson, and T. Fahey, "The use of infrared thermometry for the detection of fever.," *Br. J. Gen. Pract.*, vol. 54, pp. 448–450, 2004.

[5] Y. K Ng, G. J. L. Kaw, and W. M. Chang, "Analysis of IR thermal imager for mass blind fever screening," *Microvasc Res*, vol. 68, pp. 104–109, 2004.

[6] E. Y. K Ng, "Is thermal scanner losing its bite in mass screening of fever due to SARS," *Med Phys*, vol. 32, pp 93–97, 2005.

[7] E. Y. K. Ng, C. Chong, and G. J. L. Kaw, "Classification of humanfacial and aural temperature using neural networks and IR fever scanner: A responsible second look," *J. Mech. Med. Biol.*, vol. 5, pp. 165–190, 2005.

[8] E. Y. Ng and G. J. L. Kaw, "IR scanners as fever monitoring devices: physics, physiology and clinical Accuracy," *Biomedical Engineering Handbook*, 2006, pp. 1–24.

[9] Proviso Systems. (2014). FAQ on Thermal Imaging. [Online]. Available: http://www.proviso-systems.co.uk/section-blog/53-thermal-imaging-faq.html

[10] E. Y. K. Ng, M. Wiryani, and B. S. Wong, "Study of facial skin and aural temperature using IR with and w/o TRS," *IEEE Eng Med Biol Mag*, pp. 68–74, 2006.

[11] H. M. Azamathullah, A. A. Ghani, and N. A. Zakaria, "An ANFIS based approach for predicting the scour below split-bucket spillway," in *Proc. 2nd International Conference on Managing Rivers in 21st Century: Solutions towards Sustainable Rivers Basins Computer*, 2007, pp. 239–256.

Norulzahrah Mohd Zainudin received her bachelor of science from Universiti Teknologi Malaysia and master of science from Universiti Putra Malaysia in the year 2000 and 2003, respectively. She is currently pursuing her PhD at Liverpool John Moores University, United Kingdom.

She is a lecturer at National Defence University Malaysia (formerly known as Military Academy Malaysia) in Kuala Lumpur, Malaysia from 2002 until present. Her research interests are digital image processing, digital image forensic, forensic computing and expert system.

Suzaimah Ramli was born in Temerloh Pahang on the 1st of May 1973. She received her PhD in electrical, electronics and System engineering (image processing) from Universiti Kebangsaan Malaysia in 2011.

She started her career as a lecturer in the year 2000 at Cybernetics College Kuala Lumpur and now she is an associate professor in the Department of Computer Science at Faculty of Defence Science and Technology, National Defence University Malaysia (formerly known as Military Academy Malaysia) in Kuala Lumpur, Malaysia. Her current research interests are machine vision system, image processing and computational intelligence.

Kamarul Hawari Ghazali received his bachelor of electrical and electronics from Universiti Teknologi Malaysia and master of science from Universiti Putra Malaysia in the year 1997 and 2003, respectively. He received his PhD in electrical, electronics and system engineering (image processing) from Universiti Kebangsaan Malaysia in 2010.

He is a lecturer at University Malaysia Pahang from 2002 until present. His research interests are digital image processing, electrical, electronics and system engineering.

Kapt Muhamad Lazim bin Talib has a M.Sc in information technology (intelligent system) and B.Sc. in information technology (system engineering). His research interests are in the field of intelligent agents and robotic.

Nor Asiakin Hasbullah is a Ph.D. candidate of system science in the Faculty of Computer and Mathematical Science at the MARA University of Technology Malaysia and a lecturer in Department of Computer Science in National Defence University of Malaysia Her research interests are in the field of privacy, data protection, information security and t-government. Currently her working title of thesis/research was 'citizen-centric privacy engineering framework for transformation government'. She has published and presented four of her research findings during her preliminary search to international conferences and one has been accepted as article in an international journal.