Emotion Recognition System Adoption: A Proposed Framework

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Abstract. An emotion recognition system or ERS is an emerging technology due to its potential use in various platforms, applications and sectors. ERS is a key technology arising from the fourth industrial revolution (IR 4.0) and arguably it is becoming a key technology in enabling the fifth industrial revolution (IR 5.0). This is so because IR 5.0 main feature is personalization. The body of knowledge on ERS consists largely of works on exploring the modalities or modes to recognise or determine emotion; the development of the system itself; and the creation of applications utilising the emotion recognition functions. However, to enable the researchers and innovators to develop better and more impactful ERS, they need to understand the factors shaping usage and determining adoption amongst the intended users. This particular aspect relating to ERS is not yet fully explored and understood. Plus, there is yet to be a definitive framework or model on determinants for ERS adoption. This research intends to address this important need. Specifically, this study will look into the key adopters that will be using ERS, and propose a conceptual framework for ERS adoption. The theories underpinning the proposed conceptual framework are the Theory of Planned Behaviour (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT) and Diffusion of Innovations (DOI). It is envisioned that this research will; confirm the validity of the proposed framework and generate new findings that will benefit ERS practitioners as well as adopters.

Keywords: Emotion recognition system (ERS) · artificial intelligence (AI) · affective computing (AC) · adoption · acceptance · Malaysia

1 Introduction

Emotion recognition system (ERS) is an emerging technology in recent years due to technological advancements globally. Being part of artificial intelligence (AI) that uses computers to model intelligent behaviour with the minimal human intervention [1], ERS is one of the emerging AI technologies being introduced in the 2010s that enables a

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machine or computer to recognise and understand human emotions using affective computing (AC) [2]. Emotion recognition technology has gained the interest of researchers when they devote attention to developing systems to recognise human emotions [2].

With technological advancements such as AI already available to the end-user, emotion recognition technology can follow through as an embedded technology inside AI and can be used by the end-user. In previous research, emotion recognition technology can be determined through various modalities either multimodal or unimodal to recognize six basic human emotions such as sadness, happiness, disgust, fear, surprise and anger, based on the signal that the computer receives from the voice of speech, facial expression, hands, or body movement [3]. As machines or computers become more and more intelligent, emotion recognition systems can be seen as enhancing the machine and computer and attracting researchers' interest in developing similar systems [4].

The goal of ERS is to have an automated recognition system for the human temporal emotional state from input data modalities [5]. ERS can be seen as embedded technology in various applications that can be used for professional or individual day-to-day use. For instance, in education, ERS can be applied to monitor students' moods in a classroom [6]. Moreover, the healthcare industry can benefit from ERS as additional help, for example, ERS for specially needed people, [7] such as autistic patients that are unable to tell their feelings or described their moods, and ERS as stress management, [8] which ERS identifies mood of either stressed, depressed and anxious. ERS can be also embedded for commercial advertisement marketing purposes. For example, the emotional reactions of viewers will be measured when they are exposed to different formats of online advertisement [5]. The same method can be used for video games whereas video games are affected by the player's emotional state. With the primary goal of video games is to entertain the player [5], embedding ERS in games can help to fulfil gameplay in terms of satisfaction for the player.

In addition, the Fourth Industrial Revolution (IR 4.0), is defined as digital transformation as this digital revolution changes the way individuals live and work [9]. IR 4.0 highlighted the sustainability that can be achieved with the implementation of digitalization and technology amongst humans and led to smart factories, smart homes and a smart society [9, 10]. The impact of digitalization has created opportunities for enhancing technologies, such as the implementation of artificial intelligence (AI), big data analysis, augmented and virtual reality, and many more [11]. Therefore, ERS can be an important addition as embedded technology to the technologies that are currently been used in IR 4.0 applications.

While we are moving towards the Fifth Industrial Revolution (IR 5.0) which will be happening in the near future, ERS can be the key technology for bridging IR 4.0 to IR 5.0. For IR 5.0, the concept is still about digitalization and technology just as in IR 4.0, with the difference in the increased human-machine interaction (HCI) that is empowering people to express themselves via personalized products and services [10]. Thus, this emphasis on HCI underlines the importance and potential of ERS. ERS clearly have significant roles both in IR 4.0 and 5.0.

Focusing on the Malaysian scope where the Malaysian government introduced the IR 4.0 national framework[1] to align with the government's policy to unlock the potential of economic benefits through technological advancement. Malaysia IR 4.0 objectives focused on the area of human capital development, infrastructure development, regulations improvement, and technology adoption and innovation. The objectives of Malaysia IR 4.0 are:

1. Equip the citizens with IR 4.0 knowledge and skillset
2. Connected nation through digital infrastructure development
3. Future-proof regulations to be agile with technological changes
4. Accelerate IR 4.0 technology adoption and innovation

Including the Twelfth Malaysian Plan (12MP) by the Malaysian government[2], in which government allocates RM 45 million in technological transformation and RM 30 million for innovation hub IR 4.0, the government is committed to drive economic growth by leveraging on IR 4.0 specifically the technologies involved.

It is suggested that ERS applications have a wide range of benefits and it is a key technology in IR 4.0 as well as bridging towards IR 5.0. This aligned with the Malaysian government's policies and strategic objectives. Specifically, the government wants to accelerate IR 4.0 technologies adoption and innovation; build a holistic and inclusive digital society. Thus, ERS is seen as an important technology deserving the attention of researchers and innovators.

However, to enable the researchers and innovators to develop better and more impactful ERS, they need to understand the factors shaping usage and determining adoption amongst the intended users. This particular aspect relating to ERS is not yet fully explored and understood. Plus, there is yet to be a definitive framework or model on determinants for ERS adoption. This research intends to address this important need. Specifically, this study will look into the key adopters that will be using ERS, and propose a conceptual framework for ERS adoption. Key adopters of interest are the youths as this group nowadays are tech-savvy and the decision makers of the future. The insights will contribute to the generation of theoretical, practical, and policy recommendations for the effective diffusion of ERS in the country.

2 Literature Review

An emotion recognition system (ERS) is defined as part of artificial intelligence (AI) and uses affective computing (AC) to understand and act on human capabilities [2]. As 'affective computing' (AC) proposed by [12], is "computing that relates to, arises from and understands human behaviour". AC has significantly become an important field of study and it is the key for the researchers to enable human-computer interaction (HCI), therefore, emotion recognition is seen as an additional upgrade to the current technological advances such as artificial intelligence (AI) [13]. Artificial intelligence

[1] https://www.thestar.com.my/news/nation/2021/06/29/national-fourth-industrial-revolution-policy-to-be-launched-on-july-1.

[2] https://rmke12.epu.gov.my/bm.

(AI) is the smart machine or computer that can assist humans in productivity either in their daily lives or working environment [14]. With AI, the objectives to reach the smart industry and digital society can be achieved. Therefore, ERS as an addition to the subset of AI can be the key technology that enhanced more features of computers or machines to interact more with humans.

ERS consists of modalities such as physiological, psychological and data mining from the text. Physiological modalities consist of electroencephalography (EEG), electrocardiography (ECG) and photoplethysmography (PPG). Most of these physiological modalities are purposely for the healthcare industry. Electroencephalography (EEG) is defined as an analysis tool in neuroscience, neural engineering, and biomedical engineering that measures human brain signals through the electromagnetic behaviour of specific components [4, 15]. EEG is most likely the favourite for obtaining high accuracy data for automated emotions recognitions because EEG processes use the same concept as AI systems that used convolutional neural networks for machine learning and deep machine learning [16, 17]. EEG for emotion recognition is widely tested for detecting human emotions and it has been said that EEG can provide a cheap, portable, and simple for identifying emotions [17, 18]. ECG is commonly used by previous researchers in the field of recognizing human emotion and affective computing (AC). A previous study by [8] used ECG to detect stress and the benefit of monitoring a patient's emotional stress condition to ensure that a negative tendency is not triggered. In addition, [8] highlights that machine-based ERS is an alternative to psychological modalities such as recognizing facial expressions, gestures, and vocal traits. Another modality of physiological is PPG. PPG has been said to be more practical and suitable in real-life use compared to EEG and ECG signals, in addition to galvanic skin response (GSR) as multimodal, it can be implemented as a "wearable device that can collect signals from a person without compromising comfort and privacy" [17, 19]. Although most physiological modalities are in the perspective of the healthcare industry, PPG can be exceptional because PPG can be an indicator of a person's emotional state [19].

For psychological modalities, the modalities involve are facial recognition, speech recognition, body movement, etc. Facial recognition has gained popularity amongst ERS practitioners due to diverse applications that can be applied in the real world such as marketing purposes, security supervision, online class and gaming experience [20]. Although facial expression not only can determine the six basic emotions, from previous research using facial recognition, the facial expression can be used to determine disgust, normality, and drowsiness [21]. Speech recognition as modalities of ERS is capable to identify human feelings and "makes conventional speech emotion recognition (SER) more suitable for real-life applications" [22]. According to [23], speech recognition is reviewed as part of emotion recognition where, based on someone's voice, the computer can learn what condition they are in, therefore concluding what is the emotion of that person. In [22] study, a review on the speech emotion recognition system shows that speech recognition can detect and classify emotion if it wants to be used in an emotion recognition system, only the inability of the machine/computer to handle the real-time problem and different scenario that affect human emotions.

2.1 Application of ERS

ERS can be applied through applications and can benefit some industries due to its functions as embedded technology. Align with the industrial revolution, smart machines and computers such as artificial intelligence (AI) will benefit industries' productivity in terms of efficiency and effectiveness.

ERS applications inside education can be approached with the importance of ERS can bring in education level which benefits instructor and learner [24, 25]. Emotion has a significant influence on the relationship with performance in the perspective of a learner and instructor as described by [24], and students with positive emotions led to increasing student interest, student performance and "have higher chances at succeeding in university-level" [24]. [6], in their study suggested using a webcam inside a computer laboratory and using a facial recognition modality to identify students' moods and the results show significant differences in the student's moods. Another study by [5], suggested that based on emotion recognition technologies and the modalities, in e-learning, using a computer, instructors can see the result of their classes on how the emotional state of the student and therefore avoid boredom.

Emotions can be affected while driving due to emotions' relationship with focus, as an example, poor focus led to an increasing number of accidents [26], therefore, it has significance for ERS to be an embedded technology in cars for driving safety [26]. Furthermore, the study also used driving simulation, where there will be a virtual driving experiment to test ERS ECG-based in identifying human emotions.

In [8] study, using ECG based in healthcare spanning where ERS was implemented to "reduce stress and promote relaxation". Negative emotions as described by [8], affected human mental health. With the help of ECG-based or multimodal combination more than a modality, it can help a person with mental stress by implementing ERS to identify negative and positive emotions. In addition, ERS can be useful for disabled people. Such example [27], ERS can be seen as a supporting aid for people with certain disorders such as down syndrome, autism, and even elderly people. It will be using facial expressions in real-time video as automated emotion recognition and a computer advisor that advises on how we can react appropriately [7, 27]. In addition, [7] propose using speech recognition for ERS in specially needed people. The results show that using deep learning for emotion recognition has a significant impact.

ERS can help significantly in brand awareness, from a marketing perspective, the image and video of a product can be analyzed whether the brand is acceptable or not [28]. For example, study automated emotion recognition from a web-based system towards a web browser and recognize user emotions when they saw the advertisement video [29]. In addition, a small group of people in a room are introduced to a product, and their reactions will be recorded through ERS modalities such as facial expression, and evaluate the person's reaction whether they are happy, disgusted, or anxious [5, 29].

In another aspect, in video games, the developer of games has one objective which is to "fulfil his or her dream" while playing games either through immersive gameplay, interesting storyline, intensive graphics, and so on [5]. Implementation of emotion detection can improve engagement between entertainment agent and end-user by alternatively using multimodalities such as speech recognition and EEG which can improve

understanding of human emotions towards intangibles product such as music or movies [27].

2.2 Theoretical Framework

Several theories have been proposed and explained in previous studies on consumers' acceptance of new technologies and their intention to use them. Some of the theories that are related to technologies acceptance, intention and behaviour that are widely used are; the Technology Acceptance Model (TAM) [30], Theory of Planned Behaviour (TPB) [31], Theory on Diffusion of Innovations (DOI) [32] and Unified Theory of Acceptance and Use of Technology (UTAUT) [33].

This study will use and combine the technology adoption concept and framework to establish a theoretical framework. Firstly, in 1991, Ajzen introduced TPB which determines the behavioural intention of the person's attitude [34]. Fishbein and Azjen introduced TRA in 1975 before developed TPB which adds perceived control behaviour as a new determinant. TPB was previously used to determine social behaviour that influences a person's intended behaviour. Even for the technology acceptance concept, the previous study has used TPB theoretical framework because the determinants for TPB show the significant result for technology acceptance based on intention behavioural [35].

Secondly, DOI was introduced in 1995 by Rogers, which the theory explains "a process of which an innovation is communicated through certain channels over time among members of social channel" [32]. DOI consists of adopter categories which are Innovators, Early Adopters, Early Majority, Late Majority and Laggards. This categorization defines the stage of an individual or society's awareness and exposure to a particular technology and can be classified according to their adoption rates [36].

Lastly, UTAUT is the complete culmination of technology adoption theories originating from TAM. UTAUT has been widely used in previous studies, such examples include, using the UTAUT adoption model to determine factors for the adoption of M-payment [37] and using the UTAUT adoption model in mobile augmented reality applications [38]. In addition to using UTAUT as determinants in mobile banking applications by [39].

3 Proposed Framework

This section discusses the proposed research framework that will be used in this study to understand the research question and research objectives. Below are the research question and research objectives motivating this study.

Research questions:

1. What are the attitudes of Malaysian youth towards the emotion recognition system?
2. What are the determinants for readiness to adopt an emotion recognition system amongst Malaysian youth?

Research objectives:

1. To determine Malaysian youth's attitude towards the emotion recognition system
2. To investigate the determinants for readiness to adopt an emotion recognition system in the context of Malaysian youth

Building on the theoretical framework discusses earlier, the proposed research framework for this study brought together TPB, UTAUT and DOI as the underpinning theories. The specified research questions and objectives guided the selection.

Firstly, the key users for ERS, are recognised as the youths of the country. They are commonly seen as important technology adopters. Thus, their preferences and attitudes towards the technology would provide insights for the practitioners to accurately innovate impactful solutions.

Thus, it is recognised the most suitable theory to enable us to gain such insights and understanding is TPB. In TPB, there are three independent variables or antecedents, namely, Attitude, Subjective Norm, and Perceived Behavioural Control, towards Behavioural Intention. For this study, it is specified further as Behavioural Intention for ERS Adoption or Readiness. Attitude, in this study, will reflect on the positive or negative attitude of a user on how the compatibility of the technology to be adopted in daily usage [40]. Compatibility is referring to technology adaptability for innovation in technologies and the practices of that new technology. For Subjective Norm is the level of approval or disapproval in terms of adoption by "important others" [40]. It can be influenced by the policies of institutions, and whether the technology should be adopted to grow or achieve certain positions or ranking. Lastly, Perceived Behavioural Control is the ability to implement adoption and it will be influenced by the complexity, financial ability, and trialability of the technology [41] and depending on a user's knowledge and capacity in adopting the technology [40, 41].

Next, to gain better insights, it is believed that understand whether the structural environment plays any role in affecting the user's intention to adopt ERS. Thus, UTAUT is used to inform this aspect. Specifically, Facilitating Conditions from UTAUT is added to the research framework. It refers to which people's belief that "organizational and infrastructure can support the technology" [39]. In Venkatesh's study, facilitating conditions do not affect intention but affect user behaviour in accepting and use of the technology. Lack of assistance and support, incomplete information, and limited resources may prevent a person's acceptance and use of technology [34].

Given the importance of human-centred design in innovations nowadays, a deeper understanding of the various possible categories of users is deemed critical. DOI earlier provided the categorization of technology users according to their adoption behaviours. Thus, the categories of adopters from DOI are added to the research framework as moderators. Innovators are the high-risk taker that is ready to adopt the technology with diverse social relationships and significant social banking [36]. Early adopters are the one that will approve of adopting the technology and holds a leadership role in the social system. The early majority is not the first nor the last to adopt the innovations although they do not hold the leadership role compared to early adopters and innovators and will take a longer time to adopt the technology [42]. The late majority referred for being sceptical of the innovations and peer adoption will influence their adoption.

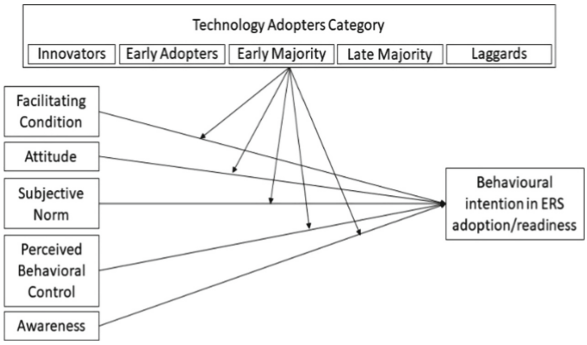

Fig. 1. Proposed Framework

Lastly, laggards are slow to adopt which they are not convinced by the technology, are financially unstable, and prefer a traditional way [42, 43]. The work aims to understand according to the different categories.

Finally, familiarity or awareness with the concept or technology is suggested as another key factor in such relationships or systems. This can be seen in numerous studies [44–46]. Thus, Awareness is added to the framework as another possible antecedent for Behavioural Intention for ERS Adoption or Readiness. Following Fig. 1 shows the proposed framework.

4 Conclusions

This study will contribute to the research gap identified in the previous study on emotion recognition system (ERS) where there is a lack of study findings on the determinants of the attitude of ERS adoption or acceptance amongst society. The previous study on ERS is focused on developing the modalities, systems and potential applications with the benefit of implementing ERS, however, there is a gap in research on who will be adopting ERS such as the consumer and end-user.

From the research gap that has been identified in this study, the expected outcome of this research potentially benefits the ERS practitioners to see the point of view of ERS in terms of users' behaviour and attitude toward ERS. Although ERS is still emerging in the last decade, the previous researcher has already identified the applications and industries that can benefit from ERS. Therefore, this study will help in identifying determinants using technology adoption theory from previous research to support the findings of this study.

Next, since the Malaysian government has introduced the new Malaysian National Fourth Industrial Revolution (IR 4.0) policy, this study is aligned with IR 4.0 policy which the government focused on accelerating IR 4.0 technology adoption and innovation. The Malaysian government policy thrust of IR 4.0 shows that the government is committed to embracing IR 4.0 technologies specifically in terms of adoption towards society. Since ERS is part of AI, and AI is an IR 4.0 technology, this study will help to found in terms of technology adoption or acceptance specifically ERS. Moreover, the Twelfth Malaysian

Plan (RMKe-12), shows initiatives from the government by allocating the budget to boost Malaysian citizens to adopt IR 4.0 technology and innovation.

With that being said, ERS is a key technology for IR 4.0 bridging towards IR 5.0, therefore, this study will help in contributing to the generation of theoretical, practical and policy recommendations for effective diffusion of ERS in Malaysia.

Thus, it can be summarised that this research's proposed framework has strong relevance to the current policies.

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