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A SCENARIO ANALYSIS OF WEARABLE INTERFACE TECHNOLOGY FORESIGHT

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ABSTRACT

Although the importance and value of wearable interface have gradually being realized, wearable interface related technologies and the priority of adopting these technologies have so far not been clearly recognized. To fill this gap, this paper focuses on the technology planning strategy of organizations that have an interest in developing or adopting wearable interface related technologies. Based on the scenario analysis approach, a technology planning strategy is proposed. In this analysis, thirty wearable interface technologies are classified into six categories, and the importance and risk factors of these categories are then evaluated under two possible scenarios. The main research findings include the discovery that most brain based wearable interface technologies are rated high to medium importance and high risk in all scenarios, and that scenario changes will have less impact on voice based as well as gesture based wearable interface technologies. These results provide a reference for organizations and vendors interested in adopting or developing wearable interface technologies.

Keywords: Wearable interface, scenario analysis, technology foresight, strategy.

INTRODUCTION

The term “wearable interface” refers to the methods and devices that are used to accommodate interaction between artificial wearable devices and the human who wears the devices. The human–machine interface of a wearable device, an accessory, a vehicle, a ship, a robot, or an industrial operation process is often referred to as the wearable interface. In a wearable device, the wearable interface can be used to deliver information from device to user, allowing user to control, monitor, record, and diagnose the user’s physical and mental status through media such as image, video, radio, software, etc.

The wearable interface industry can be considered to include vendors of technologies, products and services that enable users to access other products, resources and services. Wearable interface technologies have a major impact on the products, services and business models of the IT software and hardware industries. Wearable interface has therefore become the emerging science and technology that has drawn the most attention from the IT software and hardware industries in the wake of mobile computing era. The broad scope of the industry, as well as the fact that it spans both the enterprise and consumer markets, has led to much discussion on its future business potential as well.

Presently, major IT firms worldwide such as Apple, Google, Facebook and Intel are all exploring possible business opportunities in the wearable interface generated market. However, what is the scope of wearable interface technologies? And what are the possible outlooks in terms of the importance as well as the risks of these technologies? These key questions need to be answered before one can have confidence in the accuracy of technology strategy planning. To assist IT vendors moving forward in the emerging wearable interface market, this research aims to explore possible planning strategies for adopting or developing wearable interface related technologies. To achieve this objective, a systematic approach of scenario analysis followed by technology strategy planning is conducted.

LITERATURE REVIEW

Wearable interface technologies are diverse and numerous. Various research works have been done in this filed. In a traditional computer system such as laptop or notebook, mouse and keyboard are standard user interface devices. In recent mobile computing devices such as mobile phone or tablet, mouse is replaced by finger touch and keyboard is replaced by pen input or virtual keyboard. In the emerging wearable devices such as brace, watch and glasses, other means of user-device interface need to be employed to facilitate convenience and usability. These may include applying human voice, eye balls, touching, gesture, brain signal and even context information. In the following, research highlights of these novice interface technologies are introduced and reviewed.

Voice based wearable interface

This category of technology enables computing devices to receive, interprete and respond to human voice or natural languages. Takao et al. [25] provide unique concepts called acoustic user interface to co-ordinate and communicate more effectively multimedia information. Chua et al. [5] propose a design solution of integrating both voice and data communications wireless applications, such as mouse, headset and data port, into a single device based on Bluetooth technology. The results show that the new mouse design is introduced to reduce the data rate needed for the mouse through wireless link.

Rodger and Pendharkar [22] investigate database communication issues peculiar to users of a voice activated medical tracking application. The study exams the impact of gender, speech speed, user's technical experience and their interactions, on the performance of speech recognition system in a mobile field environment. The results indicate that the user's gender and computer experience has a significant impact on the use of voice interface as an input to a medical database of patient signs and symptoms in a mobile healthcare fieldwork environment.

Chleborad et al. [4] evaluate the voice-based data entry to an electronic health record system for dentistry by comparing three methods of storage data of the patients in the field of dentistry, including the paper dental card, a lifetime dental health record controlled by keyboard and a lifetime dental health record controlled by voice. The results indicate that the paper dental card is the most rapid method, but not the best for medical documentation and dentists.

Visuals based wearable interface

Visuals base technologies deal with the utilization of human vision and eye activities to interact with computing devices. Li and Mao [14] build the framework for Emotional eye movement generation based on Geneva Emotion Wheel for virtual agents. The results showed a higher rate of recognition of the agent intended emotion. Ramakrisnan et al. [21] evaluate user interface design of Leaning Management System by analyzing student's eye tracking pattern though the gaze plot and heat map. The analysis from the student's eye tracking pattern indicated some interface design issues in Leaning Management System.

Wu [31] review the representative theory of interactive behavior, eye tracking technologies and related studies to discuss the utilizing of interactive teaching and integrated application in technology has revolutionized ways of teaching and learning. The results indicate that the eye tracking technique can be expected to link directly together with computer and apply the immediate feedback to the learners, or teachers.

Jowers et al. [10] explores the potential of eye tracking as a computer-aided design interface for a two-dimensional sketch editor. The results are positive and indicate the potential for eye tracking as an interface for supporting shape exploration in computer-aided design. Vela´squez [28] introduces eye-tracking technologies for collecting and processing data originated by web user ocular movements on a web page. This eye-tracking tool can improve the effectiveness of the current methodology for identifying the most important web objects from the web user's point of view.

Muensterer et al. (2014) look forward to evaluate the next generation Google Glass device and provide feedback to help with the future development of a specialized Glass for tomorrow's medical and surgical community.

Wang et al. [30] use eye-tracker to track the eye-movement process for investigating how website complexity and task complexity jointly affect users' visual attention and behavior due to different cognitive loads. The results show that task complexity can moderate the effect of website complexity on users' visual attention and behavior.

Tactile based wearable interface

This category of technologies provides human interactions with devices through touching interfaces. Browne and Anand [3] investigated the effectiveness and enjoy-ability of three user interfaces used to play an iPod Touch scroll shooter video game. The empirical results show that the accelerometer based interface was the preferred interface and the interface in which participants performed best.

Irwin and Sesto [9] evaluate performance and touch characteristics of individuals with and without a movement disorder during a reciprocal tapping touch screen task, where the outcome measures include number of correct taps, dwell time, exerted force, and impulse. The results indicate that the non-disabled participants had 1.8 more taps than participants with fine motor control disabilities and 2.8 times more than those with gross motor impairments.

Rydström et al. [23] compare two contemporary types of in-car multifunctional interfaces, including a touch screen interface and an interface maneuvered by a rotary control. The simulation results show that both interfaces affected the lateral control performance, but lateral control performance deteriorated to a greater extent when the touch screen interface was used.

Radhakrishnan et al. [20] compared the performance of two finger touch-based interaction techniques, including drag state finger touch and track state finger touch, and a standard mouse device for 3D computer aided design modeling operations. The results indicated that both the task completion time and error rates are statistically the same for both the finger touch-based techniques. The mouse device outperformed both the finger touch-based techniques and yielded statistically better results in terms of task completion time and error rates.

Gesture based wearable interface

Gesture based wearable interface are innovative technologies originated from gaming devices. This category of technologies employs sensing devices to detect, recognize and predict human hand, arm or body movement. Nilsson [18] presents the collection of user interface design patterns for mobile applications. One important finding indicated that the patterns collection is best suited for experienced wearable interface developers wanting to start developing mobile UIs.

Kurita and Nishikubo [11] propose a non-contact technique for the measurement of human hand motion for applications human-machine interface. This technique can be used to detect the difference of electrostatic induction current, and the direction and velocity of subject's hand movement.

Alvarez-Santos et al. [1] present the gesture-based interaction with voice feedback for a tour-guide robot. The guide robot was successfully tested in several real world environments.

Brain based wearable interface

This category of technologies aims at transforming human brain activities into instructions for conducting devices. Coffey et al. [6] overview of brain–machine interfaces approaches and explore suggestions for space applications. The study suggests that the performance limitations of current Brain–machine interfaces may reflect the incomplete information of non-invasive signals rather than merely a lack of maturity of the technology. Iáñez et al. [8] describes a spontaneous non-invasive electroencephalography based brain–machine interfaces. The results show that the efficiency and accuracy with six users have been evaluated making different experimental tests. Lee et al. [12] propose a new brain computer interface method combined with eye tracking for 3D interaction to analyze depth navigation, including selection and two-dimensional gaze direction. The results indicate that the feasibility of the proposed 3D interaction method using eye tracking and a brain computer interface.

Leeb et al. [13] transfer brain-computer interfaces beyond the laboratory, and application control for motor-disabled users. The results show that all participants who achieved good BCI performances could also control the applications successfully. Úbeda et al. [27] describe a Shared control architecture based on RFID to control a robot arm using a spontaneous brain–machine interface. In this study, a six degrees of freedom robot arm with a gripper attached on its end effector is controlled using an spontaneous brain–machine interfaces to perform pick and place operations. The results show that four volunteers have successfully controlled the robot arm.

Vourvopoulos and Liarokapis [29] evaluate the commercial brain–computer interfaces in real and virtual world environment. The results indicate that robot navigation through commercial brain-computer interfaces can be effective and natural both in the real and the virtual environment.

Context based wearable interface

Context based technologies make use of possible sensing and recognition of context information to interact with devices. Perrin et al. [19] propose a novel semi-autonomous navigation strategy designed to minimizing the user involvement. The results show that the navigation strategy is successfully tested both in simulation and with a real robot for low throughput interfaces.

Mascarenas et al. [15] explore a new paradigm-cooperative human-machine structural health monitoring. The premise of this paradigm is the idea that a human cooperating with a machine will always significantly outperform a machine or human acting independently. Cuin and Honkala1 [7] experimented with integration of web-based social networking services into mobile devices' main user interface. The results indicate that it is feasible to construct an alternative device wearable interface that supports integration of Web content across applications and services via hyper-linking.

Broll et al. [2] investigate the design, usability and user experience of multi-user interactions on dynamic Near Field Communication (NFC)-displays, and evaluated the performance of dynamic NFC-displays, interactions among users and the interplay between mobile devices and large displays. Neira et al. [17] propose an Adaptive Human Machine Interfaces (HMI) Builder to incorporate in most of the Android devices in the market.

Tesoriero et al. [26] propose a novel solution that combines social software with context awareness to improve users' interaction in public spaces, such as mobile devices and RFID.

RESEARCH METHOD

Scenario Analysis

Scenario Analysis (SRI [24]) has been applied in various domains for forecasting trends in the development of technology. Different versions scenario analysis methods have been proposed (Mietzner and Reger [16]). It is employed in technology portfolio planning process (Yu [32]) to assist in the strategic decision necessary for finding the feasible plan of resource allocations among available technologies that best fits the goal of an organization. Scenario Analysis is also a method used by futurists to develop future situations in order to facilitate strategic action plans and to create visions for the future.

The key steps of scenario analysis process are as follows.

1. Identify significant impact variables for scenario construction.
2. Propose possible scenarios by exploring combinations of impact variables.
3. Construct a set of technology alternatives and classify them into groups.
4. Generate a set of technology assessment indicators.
5. Evaluate the technology alternatives by technology assessment indicators.

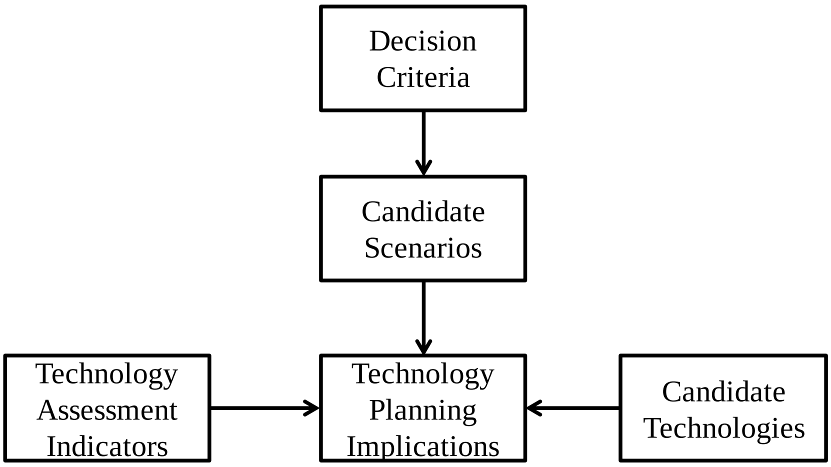

Figure 1. Research framework of a technology planning study.

Expert Panel

To conduct the technology foresight study, an expert panel was selected with fifteen domain experts selected from the IT industry. This expert panel consisted of the following members:

1. Three R&D managers of publicly listed wearable device manufacturers.
2. Three consultant managers of publicly listed IT services firms.
3. Four CEO and VP level executives of independent software vendors.
4. Two project managers of publicly listed telecom operators.
5. Two product managers of publicly listed sportswear.
6. One member of technical staff of government supported think tank.

A facilitator led the expert panel discussion sessions by following the steps above. Activities in these sessions included open discussions, anonymous voting, as well as the administration of surveys.

RESULT

Decision Criteria

To identify decision making criteria, expert panel discussions were conducted concerning decision making factors from the social, political, economic and technological perspectives. Possible decision factors were discussed, such as the market outlook for a technology, as well as the competence of the industry to acquire this technology. The final set of indicators is summarized in Table 1.

Table 1. Major decision factors

Decision factors	Issues
Social factors	1. Availability of wearable device for quality of life improvement for general public
Technological factors	1. Entrance barrier level of wearable interface technology 2. R&D strength of the local wearable device industry
Economic factors	1. Strategic benefit of the enterprises adopting wearable interface technologies 2. New business opportunity for the local wearable device industry
Political factors	1. Strength of wearable interface technology enhancement policies of government

Candidate Scenarios

There are many different scenario alternatives which organizations may select for wearable interface technology trends. Impact variables which are most likely to affect the scenario development were identified by the expert panel. Through evaluations from different combinations of these variables, final choices of scenarios were then determined. After the Expert Panel discussions, the scenarios were labeled and elaborated upon. The results are illustrated in Table 2.

Table 2. Candidate Scenarios

Global Market Outlook	Technology Breakthrough	Vendor Competition	Final Scenario Choice and Naming
Good	Fast	High	Big Torrent
Poor	Fast	High	
Good	Slow	High	Sluggish Stream
Poor	Slow	High	
Good	Fast	Low	
Poor	Fast	Low	

Global Market Outlook	Technology Breakthrough	Vendor Competition	Final Scenario Choice and Naming
Good	Slow	Low	
Poor	Slow	Low	

A detailed description of the scenarios is as follows.
1. Scenario: Big Torrent
In the Big Torrent scenario, the foreseen global economic situation is strong, and the worldwide IT spending outlook is in good shape. At the same time, with the progress of continuous research in both industry and academia, the development of wearable interface technology is experiencing a major breakthrough.
2. Scenario: Sluggish Stream
In the Sluggish Stream scenario, the foreseen global economical situation is strong, and the worldwide IT spending outlook is in good shape. However, the progress of academic and industrial wearable interface technology research and development is slow. As a result, potential users may relocate their resources to other areas with more promising technologies.

Candidate Technologies
To assess the possible wearable interface technologies for the proposed scenarios, another technology expert panel of twelve members was formed. This panel differed from the previous panel. The purpose of a different expert panel was to assure independence between technology planning activities. Wearable interface technology data were collected by interviewing these panel members, as well as from secondary data which included vendor propositions and research literature. The final list of the most promising wearable interface technologies is exhibited in table 3.

Table 3. Candidate Wearable Interface Technology

Category	Technology
Voice based wearable interface (VO)	VO1: Voice recognition VO2: Voice synthesis VO3: Natural language processing VO4: Audio display VO5: Acoustic wearable interface
Visual based wearable interface (VI)	VI1: 3D visualization and 3D printing VI2: Eye tracking VI3: Video streaming VI4: Eye gaze based interaction VI5: Infographics
Tactile based wearable interface (TA)	TA1: Touch screen technology TA2: Finger-based multitouch interface TA3: Wearable sensor computing TA4: Fingerprint interface TA5: Haptics feedback technology
Gesture based wearable interface (GE)	GE1: Hand and arm gesture interface GE2: Hand recognition interaction GE3: Gesture and motion based gaming GE4: Data glove technology GE5: Motion capture technology
Brain based wearable interface (BR)	BR1: BCI (brain-computer interface) BR2: EEG (electroencephalogram) applications BR3: Brain-robot interface BR4: Neural network technology BR5: Steady State Visually Evoked Potentials (SSVEP) applications
Context based wearable interface (CO)	CO1: Facial tracking CO2: Virtual reality CO3: Multimodal interaction CO4: Augmented reality CO5: Perceptual wearable interface
Total count	30

Technology Assessment Indicators
The expert panel on technology then applied the scenario analysis approach to assess the candidate wearable interface technologies of the six major clusters in two dimensions: importance and risk. These two dimensions are quantified by selected indicators summarized in Table 4.

Table 4. Technology Assessment Indicators

Dimensions	Indicators	Low Level	Medium Level	High Level
Importance	Annual growth rate of global market size for the next 5 years	< 10%	10%~30%	> 30%
	Global user adoption ratio	< 10%	10%~70%	> 70%
Risk	Annual growth rate of local production value for the next 5 years	> 10%	10%~5%	< 5%
	Local R&D budget over revenue proportion	> 10%	10%~3%	< 3%

Technology Planning Implications

Based on the important indicators and risk indicators in Table 4, the expert panel assessed the wearable interface technologies compiled in Table 3 with respect to the four scenarios. The assessment results are exhibited in figures 2-3 and discussed as follows.

1. Technology Planning Implications for Scenario Big Torrent

For the Big Torrent scenario, the assessment outcome is depicted in Figure 2. In this scenario, the gesture based (GE) wearable interface technologies would be of high importance and low or medium risk in general. This is mainly because the gesture based wearable interface technologies, based on the development of gaming devices, mobile devices and location based services, are becoming popular on new mobile devices as well as wearable devices, and have a large base of users worldwide. Also note the brain based (BR) wearable interface technologies are positioned in both high importance and high risk. Though these technologies are viewed as the big opportunity for the IT industry, these technologies are also new and highly competitive to most enterprises, and the adoption of them is considered highly risky.

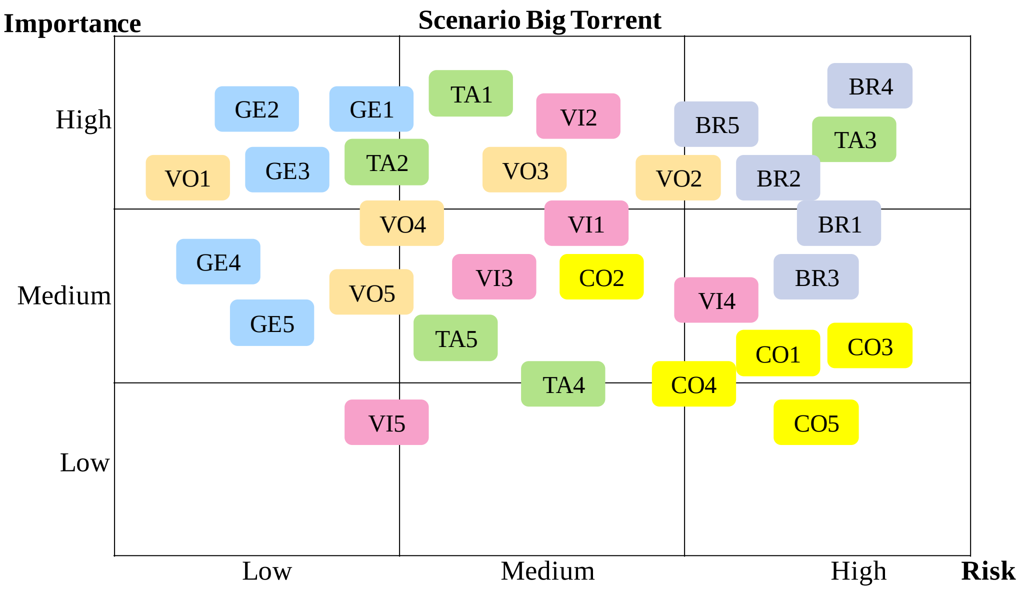

Figure 2. Technology assessment for Scenario Big Torrent

2. Technology Planning Implications for Scenario Sluggish Stream

For the Sluggish Stream scenario, the assessment outcome is depicted in Figure 3. In this scenario, the risk of most technologies would increase in general compared with the Big Torrent scenario. The context based (CO) wearable interface technologies, based on the development of context computing model, would have decreased importance. In general, the visuals based (VI) wearable interface technologies would also have lower importance, due to the possible slow advancement of 3D technology development.

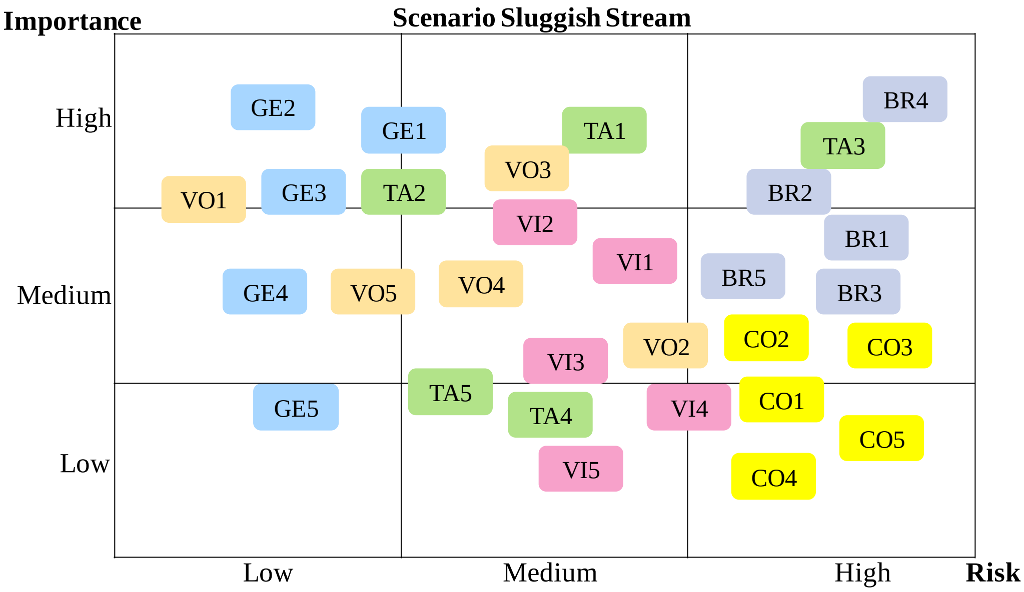

Figure 3. Technology assessment for Scenario Sluggish Stream

CONCLUSION

In this study, a systematic approach geared towards deriving foresight towards possible wearable interface technology developments over the next five years was conducted. Based on these results, the strategic thinking of an organization toward developing or adopting wearable interface technologies for competitive advantages can be initiated. For example, these findings suggest that voice based (VO) and gesture based (GE) wearable interface technologies should have a higher priority for organizations in the pursuit of new market opportunities. Hand and arm gesture interface (GE1), Hand recognition interaction (GE2), Gesture and motion based gaming (GE3), Finger-based multi-touch interface (TA2) and Voice recognition (VO1) are of the highest importance and lowest risk, and they are also most robust to scenario changes.

On the other hand, vendors interested in exploring the market opportunities of wearable interface technologies can use the analysis framework and outcome of this research as a reference for their strategy planning, thereby avoiding many unnecessary trial and error marketing efforts. In particular, with a clear picture of the wearable interface technologies scenario analysis, vendors can better position themselves for the most suitable market sector in terms of importance and risk.

REFERENCES

[1] Alvarez-Santos, V., Iglesias, R., Pardo, X.M., Regueiro, C.V. and Canedo-Rodriguez, A. (2013) 'Gesture-based interaction with voice feedback for a tour-guide robot', *Journal of Visual Communication and Image Representation*, Vol. 25, No. 2, pp. 499-509.

[2] Broll, G., Vodicka, E. and Boring, S. (2013) 'Exploring multi-user interactions with dynamic NFC-displays', *Pervasive and Mobile Computing*, Vol. 9, pp. 242-257.

[3] Browne, K. and Anand, C. (2012) 'An empirical evaluation of user interfaces for a mobile video game', *Entertainment Computing*, Vol. 3, pp. 1-10.

[4] Chleborad, K., Zvara Jr., K., Dostalova, T., Zvara, K., Hippmann, R., Ivancakova, R., Zvarova, J., Smidl, L., Trmal, J. and Psutka, J. (2013) 'Evaluation of voice-based data entry to an electronic health record system for dentistry', *Biocybernetics and Biomedical Engineering*, Vol. 33, No. 4, pp. 204-210.

[5] Chua, C.L., Koh, K.S., Chong, P.H.J., Shum, P., Tong, Y.C., Wang, X.Y., Zuo, Y.X. and Kuek, H.W. (2003) 'Embedded human interface device for voice and data communication', *Proceedings of the 2003 Joint Conference of the Fourth International Conference on Information, Communications and Signal Processing*, Vol. 1, pp. 362-368.

[6] Coffey, E. B.J., Brouwer, A.M., Wilschut, E.S. and van Erp, J.B.F. (2010) 'Brain–machine interfaces in space: Using spontaneous rather than intentionally generated brain signals', *Acta Astronautica*, Vol. 67, pp. 1-11.

[7] Cuin, Y. and Honkala1, M. (2013) 'A novel mobile device user interface with integrated social networking services', *International Journal of Human-Computer Studies*, Vol. 71, pp. 919-932.

[8] Iáñez, E., Azorín, J.M., Úbeda, A., Ferrández, J.M. and Fernández, E. (2010) 'Mental tasks-based brain–robot interface', *Robotics and Autonomous Systems*, Vol. 58, pp. 1238-1245.

[9] Irwin, C.B. and Sesto, M.E. (2012) 'Performance and touch characteristics of disabled and non-disabled participants during a reciprocal tapping task using touch screen technology', *Applied Ergonomics*, Vol. 43, pp. 1038-1043.

[10] Jowers, I., Prats, M., McKay, A. and Garner, S. (2013) 'Evaluating an eye tracking interface for a two-dimensional sketch editor', *Computer-Aided Design*, Vol. 45, pp. 923-936.

[11] Kurita, K. and Nishikubo, K. (2009) 'Development of a human motion measurement system for application to the human

machine interface', *Proceedings of 2009 International Joint Conference on ICROS-SICE*, pp. 5552-5555.
[12] Lee, E.C., Woo, J.C., Kim, J.H., Whang, M. and Park, K.R. (2010) 'A brain–computer interface method combined with eye tracking for 3D interaction', *Journal of Neuroscience Methods,* Vol. 190, pp. 289-298.
[13] Leeb, R., Perdikis, S., Tonin, L., Biasiucci, A., Tavella, M., Creatura, M., Molina, A., Al-Khodairy, A., Carlson, T. and Millán, J.d.R. (2013) 'Transferring brain–computer interfaces beyond the laboratory: Successful application control for motor-disabled users', *Artificial Intelligence in Medicine,* Vol. 59, pp. 121-132.
[14] Li, Z. and Mao, X. (2012) 'Emotional eye movement generation based on Geneva Emotion Wheel for virtual agents', *Journal of Visual Languages and Computing,* Vol. 23, pp. 299-310.
[15] Mascarenas, D.D.L., Choi, Y.S., Kim, H.C., Pekedis, M., Hong, S.C., Lee, J.R. and Farrar, C.R. (2013) 'Development of a novel human-machine interface exploiting sensor substitution for structural health monitoring', *Proceedings of 2013 22nd IEEE International Symposium on Robot and Human Interactive Communication,* pp. 334-335.
[16] Mietzner, D. and Reger, G. (2005) 'Advantages and disadvantages of scenario approaches for strategic foresight', *Int. J. Technology Intelligence and Planning,* Vol. 1, No. 2.
[17] Neira, O., Lee, A.N., Lastra, J.L.M. and Camp, R.S. (2013) 'A builder for Adaptable Human Machine Interfaces for mobile devices', *Proceedings of 2013 11th IEEE International Conference on Industrial Informatics,* pp. 750-755.
[18] Nilsson, E. G. (2009) 'Design patterns for user interface for mobile applications', *Advances in Engineering Software,* Vol. 40, pp. 1318-1328.
[19] Perrin, X., Chavarriaga, R., Colas, F., Siegwart, R. and Millán, J.d.R.(2010) 'Brain-coupled interaction for semi-autonomous navigation of an assistive robot', *Robotics and Autonomous Systems,* Vol. 58, pp. 1246-1255.
[20] Radhakrishnan, S., Lin, Y., Zeid, I. and Kamarthi, S. (2013) 'Finger-based multitouch interface for performing 3D CAD operations', *International Journal of Human-Computer Studies,* Vol. 71, pp. 261-275.
[21] Ramakrisnan, P., Jaafar, A., Razak, F.H.A and Ramba, D.A. (2012) 'Evaluation of user interface design for leaning management system (LMS): Investigating student's eye tracking pattern and experiences', *Procedia - Social and Behavioral Sciences,* Vol. 67, pp. 527-537.
[22] Rodger, J.A. and Pendharkar, P.C. (2007) 'A field study of database communication issues peculiar to users of a voice activated medical tracking application', *Decision Support Systems,* Vol. 43, pp. 168-180.
[23] Rydström, A., Broström, R. and Bengtsson, P. (2012) 'A comparison of two contemporary types of in-car multifunctional interfaces', *Applied Ergonomics,* Vol. 43, pp. 507-514.
[24] SRI. (1996) 'Integrated Technology Planning', *SRI International Report,* Menlo Park, California.
[25] Takao, H., Sakai, K., Osufi, J. and Ishii, H. (2002) 'Acoustic User Interface (AUI) for the auditory displays', *Displays,* Vol. 23, pp. 65-73.
[26] Tesoriero, R, Villanueva, P.G., Fardoun, H.M. and Rivera, G.S. (2014) 'Distributed user interfaces in public spaces using RFID-based panels', *International Journal of Human-Computer Studies,* Vol. 72, pp. 111-125.
[27] Úbeda, A., Iáñez, E. and Azorín, J.M. (2013) 'Shared control architecture based on RFID to control a robot arm using a spontaneous brain–machine interface', *Robotics and Autonomous Systems,* Vol. 61, pp. 768-774.
[28] Vela´squez, J.D. (2013) 'Combining eye-tracking technologies with web usage mining for identifying Website Keyobjects', *Engineering Applications of Artificial Intelligence,* Vol. 26, pp. 1469-1478.
[29] Vourvopoulos, A. and Liarokapis, F. (2014) 'Evaluation of commercial brain–computer interfaces in real and virtual world environment: A pilot study', *Computers and Electrical Engineering,* Vol. 40, pp.714-729.
[30] Wang, Q, Yang, S., Liu, M, Cao, Z. and Ma, Q. (2014) 'An eye-tracking study of website complexity from cognitive load perspective', *Decision Support Systems,* Vol. 62, pp. 1-10.
[31] Wu, C.I. (2012), HCI and Eye Tracking Technology for Learning Effect, *Procedia - Social and Behavioral Sciences,* Vol. 64, pp. 626-632.
[32] Yu, O. (2006) *Technology Portfolio Planning and Management*, Springer Publisher.