Preventing Duplication of Digital Music File Using a New Cognitive and Constructive Learning Approach

Hammuzamer Irwan Hamzah, Low Tan Jung, and Ariffin Abdul Mutalib

Abstract—A new method is required to prevent duplication when digital musical data are inserted onto the hard disk. Currently, the digital music duplication detection application can detect duplication of digital music records on the hard disk, but unfortunately, duplication still happened. Using these applications, the replicate digital music files can be searched and moved into other folders. The user needs to manually delete these files. This study presents a new approach called the Cognitive and Constructive Learning (CCL) approach to preventing duplication from occurring when a digital music file is inserted onto a personal device. This study reviews and adapts the requirements of the digital music technology, as well as the human recognition and learning concepts. The main objective of this study is to propose a model known as the Digital Music Archiving Model (DMAM) in preventing duplication of the digital music file on a personal device based on the new CCL approach. A comparative analysis is conducted between the DMAM and the existing digital music duplication detection applications. Review by focus group is also sought to assess the most important part of this research work. The results obtained show that the DMAM is capable of preventing duplication of digital music files on a personal device based on the new CCL approach better than the benchmarked methods. The hard disk of the personal device can offer extra spaces for digital music records archiving.

Index Terms—Software engineering, multimedia database, digital music file.

1 Introduction

A preliminary study is conducted to see the preferences towards the model. A survey is conducted, and analysis of the collected data is performed. A total of 196 respondents participated in this survey. The instrument used is a questionnaire. As a result, some of the significant findings of this survey are; 95.92% of the respondents store digital music files on their personal device, 72.96% of the respondents have the experience of having duplication of digital music file on their personal device, 69.23% of the respondents have no experience in using digital music duplication detection applications to find duplication files, and 77.04% of the respondents prefer having DMAM to prevent duplication of digital music file from occurring on their personal device. So, it provides an indication that there is a need to carry out a study relevant to the creation of DMAM.

2 Literature Review

The theoretical framework is a collection of interrelated concepts. It guides for the development of the CCL approach. It is built based on the collaboration of the digital music technology together with human recognition and learning concepts. The requirements from these ideas are identified and introduced, and they are listed as the requirements for developing the CCL approach. From the literature reviews made in this study, the digital music technology together with the human recognition and learning concepts, bring to the development of the CCL approach and the DMAM. Theoretically, this study believes that, with DMAM, it makes a personal device be free with duplication of digital music files. The literature reviews also cover the solution of the problem of this study. This study comes out with a plan that is able to portray the agendas or to prevent duplication of a digital music file on a personal device. It visualizes the collaborative and comprehensive requirements from the concepts chosen. This study then converts the theoretical framework of the CCL approach as well as the DMAM. As a conclusion, the theoretical framework provides the guideline for the development of the CCL approach. It also stimulates the directions and

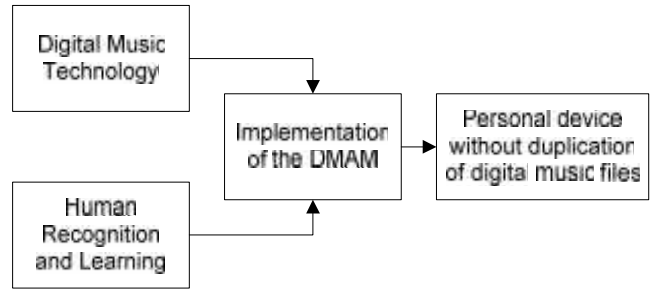

Fig. 1. Theoretical framework

- *Hammuzamer Irwan Hamzah is with the School of Multimedia Technology and Communication, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia. E-mail: zamer@ uum.edu.my*
- *Low Tan Jung is with the Computer and Information and Sciences, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak, Malaysia. E-mail: lowtanjung@petronas.com.my*
- *Ariffin bin Abdul Mutalib is with the School of Multimedia Technology and Communication, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia. E-mail: am.ariffin@ uum.edu.my*

strategies of implementing the DMAM to secure the personal device without the duplication of digital music files occurrence. It also results in the elicitation of the focus of the study.

2.1 Review of Digital Music Technology Concept

Digital music software is the foremost thing that is observed. This study pursues to develop a process for preventing duplication of a digital music file from happening on the personal device. [1] said that the problems with having a large digital music collection are that the user may have duplications on their personal device. Trying to discover duplicate files by listening to full digital music records is impractical. An additional approach is to use software tool. Digital music duplication detection applications can be used in this situation for reclaiming lost hard disk space by cleaning the music library. There are two kinds of different digital music software / tools; they are digital music duplication detection applications and digital music software. There are also many modern software media players such as iTunes, Winamp, or Windows Media Player. These software(s) offer essential tools for organizing, as well as playing the media. There is also free digital music managers' software for working with MP3 libraries such as Media Monkey Standard, Helium Music Manager, or MusicBee, and many others [1]. From other reviews made for the commenced problem, there is a number of digital music software that detects duplication of the digital music file and cleans the hard disk of a personal device from duplication files. It is necessary for a good organization of a significant collection of the digital music on a personal device by using these application tools.

Besides that, this study also discovers that there are many categories of other digital music software. This study searches digital music duplication detection applications to recognize how preventing the duplication of the digital music file in the personal file is executed. This study also investigates on how the software(s) execute the duplication detection function. There are numbers of digital music duplication detection applications discovered from this work, and they are broken down and critiqued. These application tools are seen to obtain information, especially on the process of how the duplication prevention action executes. The reviewed and analyzed digital music duplication detection applications that help in tidying up digital music collection are Abee MP3 Duplicates Finder [2], dupeGuru Music Edition [3], Duplicate Cleaner – Find Duplicate Files [4], Duplicate Music Finder [5], MusicBee – Music Manager and Player [6], Similarity [7], and TuneUp [8]. There are contributions and limitations for each of the digital music duplication detection applications. This study performs further analysis and extracts the requirements that the duplication music finder must endure. The requirements are then adapted for the development of the CCL approach.

2.2 Analyzing the Requirements for CCL Approach and DMAM

This study defines the chosen requirements in the way that is appropriate for the developmental process. These requirements are categorized following the separate ideas of the literature study performed. This study tables the requirements of the digital music technology for creating the CCL approach and DMAM. The requirements of the digital music technology concept are shown in TABLE 1. On another note, the requirements of the human recognition and learning concept are shown in TABLE 2.

TABLE 1. FINDINGS FOR THE REQUIREMENTS OF DIGITAL MUSIC TECHNOLOGY

Requirements.	Descriptions.
Digital music file [9], [10].	To offer manipulation of digital music records.
Data modeling [9], [10].	To create a new form of audio data modeling based on the human recognition and learning concept.
Classification [11].	To establish a newly created classification process known as the CCL approach.
The user interface [9].	To establish user interfaces to receive the stored digital music file and to provide support for any user involvements.
Storage [9].	To establish an optimized storage on a personal device from the duplicate file.
Fingerprinting [12].	To offer matching and retrieving process.
Semantic-based retrieval [13].	To give semantic-based matching and retrieving process.
Content-based retrieval [13].	To give content-based matching and retrieving process.
Object recognition [14].	To offer object-oriented matching and retrieving process.

TABLE 2. FINDINGS FOR REQUIREMENTS OF HUMAN RECOGNITION AND LEARNING

Requirements.	Descriptions.
Human ear [15].	To establish an interface based on the human ear only to receive the information about the digital music file to be stored in the device storage.
The human brain [16].	To establish a central processor such as to recognize and learn, to store, to provide information, and to display output based on particular human brain's learning functions (based on the human recognition and learning concept), not the holistic brain functions and memory storage source.

Memory structure [17]–[19].	To provide an interface, processor, and storage.
Familiarity [20].	Forming the process and storage for recognized records.
Recollection [20].	Forming the process and storage of cognitive learning and constructive learning records.
Recognition [20].	To match the inserted record with a record in storage.
Cognitive learning [21].	To receive the updated record.
Constructive learning [22].	To receive the newly inserted record.

2.3 Mapping the Requirements

Particular modifications are made to the particular requirements to make the CCL approach perform as it is supposed to function upon the stage of current digital music technology storage and use. The mapping of the human ear and human brain are made to extract the features of how the human recognizes and learns the signal sound. The ability of humans to accept newly corrected information is also mapped into the CCL approach. The human ability to judge right or wrong information to be accepted is also plotted in the CCL approach, in which is developed to process the best informative data that could be controlled only by human judgment, and any error occurred is made by human failure to support the digital music file storing process. TABLE 3 defines the requirements and descriptions of the mapping table.

TABLE 3. MAPPING TABLE

Requirements.	Descriptions.
Human Ear [15].	Provides interface to accept an inserted data.
Human Brain [16].	Provides the ability to manipulate, store and present the data processing. Provides processor and storage.
Recognition [20].	A matching process of an articulated record that is similar to the inserted record.
Cognitive Learning [21].	The process to replace (not updating, but a totally new record addition) a related recall memory list with a newly added record by inserting a record in the history memory.
Constructive Learning [22].	The process to receive any none matched record as a new useful record for future recognition.

The audio signal pathway from the outer ear to the middle ear, and at that point to the inner ear is investigated. The sound signal continues to move to the brain as a memory storage idea is inspired. The human ear acts as the interface to receive information. Take note that the details of the human ear, especially, its entities, features, or functions are not to be used for the model development. Sound signal travels through the human ear and goes to the brain [23] to be processed and remembered if needed [17]. It provides an interface for the digital music file to the hard disk. It is supposed to configure each file format before the storing management process is made. This study adopts the human ear mechanism. Likewise, other biologically inspired researches on digital audio adapt the human ear for accepting an inserted digital audio data. They acclimated an implementation of the ear as the interface for their research solutions to receive digital sound signal, and then make use of the ear as filtering mechanism [23]–[32]. This study corroborates the human ear's function as a system interface for accepting data.

Certain control structures of the human brain are adapted for the development of the CCL approach. Only the ability to recognize and learn any sound by the human brain [20] is adapted. Moreover, the experience of the human brain to remember for a long time [18], [19], specifically in the LTM is also considered. The CCL approach also adapts two advanced features of the human brain. The first is allowing the CCL approach to building up three distinct parts; the interface, the processor, and the storage. The researches and philosophies from [17]–[19], [33] support the organization of the CCL approach for this kind of structure. Secondly, the human brain function is also adjusted for providing the progressive features of processing and storing memory. These conditions have been reinforced from the researches [16], [20], [34]–[37] made on the human brain memory and processes. So, some of the human brain functions that corroborate this study are adapted to the requirements. The selected brain functions are the recognition and the learning functions. The recognition process of the CCL approach should work similar to the way the human brain does.

According to [20], the human brain is adept at recognizing any heard sound by comparing it with the permanent audio memory in the brain storage. At this instant, the recognition process provides the ability to remember any similar memory as articulated information. Additionally, the recognition memory is supported by two forms of memory which are the familiarity and recollection. So, these requirements are essential for the CCL approach. The recognized record is from the familiarity in the recognition memory where the inserted record is a perfect match to a record on the hard disk. Vice versa, the recollection of the recognition memory falls into the other view, where the inserted record only matches many features with the records on the hard disk. Searching articulation can be performed with only a single test if the record is perfectly matched. If the matching process is not a perfect match, this matching condition should be moved into the recollection part in the recognition memory.

For the recollection of the recognition memory of the CCL approach, two new learning are established; they are

the cognitive learning perspective and the constructive learning perspective. They are capable of portraying the recollection of the recognition memory process. The cognitive learning process is triggered when there is little support for information about any heard sound with the memory in the brain storage. The brain updates the new record with new profile information. As a result, update learning occurred. This process ignites when there is only a little support from memory / database. It provides the ability to replace the suggestions listed from the memory with new useful information. The agreement to changes improvises for better responses [21]. So, it can provide a user support decision to give a fresh material as an articulated data rather than the previous memory. In addition, the cognitive development improvises learning [38]. If the cognitive learning process is executed, searching articulation could be performed if there is acceptation to update the memory / database records with the new information. Therefore, a successful searching could be matched in the second searching.

On top of that, other researches that have given response towards cognitive learning studies [21], [35], [36], [39], [40] become the inspiration and ideas for the cognitive learning function of the CCL approach. The constructive learning process starts when there is no support for the heard sound. The new sound is carrying new information and the brain accepts it to be memorized as new sound and it is to be kept in the brain storage for future recognition, and this acceptation is totally for new sounds. Here, a new learning occurred. This procedure ignites when there is no information about the new sound found in the memory / database. It offers an indication for adding new records, and the insertion process can begin. Constructive learning also improves support for the recognition process [41] by the recognition of new records. It provides user support decision to accept the new additional information as an articulated data for future recall. This process helps the improvisation of learning [22] for the CCL approach. Searching articulation could be improved when the searching trial failed for the second time. It could be achieved by the acceptation to update the memory records with an additional new record of a different kind from that on the hard disk.

On the whole, further investigations [22], [41], [42] are needed for building the constructive learning for the requirements of the CCL approach. This study also analyzes the information on the cognitive and constructive learning. TABLE 4 provides the analysis of the cognitive and constructive learning. DMAM should facilitate the support of storing the digital music file. From the constructive learning perspective, the user should be given opportunities to explore and acquire knowledge that they want. This knowledge must be the outcome of the matching information from what is provided by the user against what is deposited in the system. With the cognitive and constructive learning features, they assist the user in making a selection of what to store. The cognitive and constructive learning features are the main aspects of the features of DMAM. TABLE 5 delineates the cognitive and constructive learning features in the implementation of DMAM.

TABLE 4. ANALYSIS OF COGNITIVE AND CONSTRUCTIVE LEARNING

Aspects.	Cognitive Learning.	Constructive Learning.
Proponents.	George Miller and Gagne.	Dewey, Piaget, Bruner, and Vygotsky.
Philosophy.	Learning is a change in knowledge stored in memory. The process of selecting information. (Attention), translating information (Encoding), and recalling that information when appropriate (Retrieval).	Learning is the process where individuals construct new ideas or concepts based on prior knowledge and/or experience. Individuals construct knowledge by working to solve realistic problems, usually in collaboration with others.

TABLE 5. COGNITIVE AND CONSTRUCTIVE LEARNING FEATURES

Aspects.	Cognitive Learning.	Constructive Learning.
Features of DMAM.	Organize new information. Link new information to the existing knowledge. Use techniques to guide and support users' attention, encoding, and retrieval process. Provide good interface.	Model and guide the knowledge construction process. Provide good interface.

3 METHODOLOGY

This study adopts the Design Science Research Methodology (DSRM), which is also known as the "Improvement Research", and this designation emphasizes the problem-solving / performance-improving nature of the activity [43] to support the prevention of digital music file duplications on a personal device by the DMAM based on the CCL approach. There are many methods and results of each phase [44], [45]. The approach delineates the phases running in the methodology. Five major phases are performed in order to achieve the research objectives, which encompass awareness of problem, suggestion, development, evaluation, and conclusion. Each phase is described further with details of the activities involved during the study. This study maps the requirements, which are identified and attained earlier. The CCL approach only focuses on storing management process for preventing

duplication on a personal device. It is unlike any other research on digital music technology or learning process because it familiarizes with a new kind of recognition and learning process. The CCL approach provides special mechanisms which are the cognitive and constructive learning components in the learning structure for supporting the recognition process. It enhances the number of getting articulate matching by not limiting the recognition process. In the suggestion phase of organizing the CCL approach, the activities are observing the digital music software, analyzing the requirements of the CCL approach, and mapping the gathered requirements for the CCL approach. In the development phase of organizing the CCL approach, the activities are organizing the matching mechanism, organizing the matching condition, organizing the flow of the matching condition, organizing the CCL flowchart, and formulating the CCL algorithm. In the evaluation phase of organizing the CCL approach, the activities are a case study of 114 Surahs in the Al-Quran, a case study of 50 random MP3 music files, interfaces of the experiments of the case study for assessing the CCL approach, and assessing the organization of the CCL approach using the review by focus group. This study also designs a model that can prevent duplication of digital music files on a personal device, known as the DMAM. In the awareness of the problem, the activity for organizing the DMAM is observing the current process to store the digital music files. In the suggestion phase of organizing the DMAM, the activity is designing the DMAM. In the development phase of organizing the DMAM, the activity is creating the conceptual model for the DMAM. In the evaluation phase of organizing the DMAM, the activities are test cases of adding the new file – constructive learning, a test case of matching the same record – recognition, test cases of adding the new file – cognitive learning, and assessment of the organization of the DMAM using the review by focus group.

This study analyzes and identifies the requirements for the CCL approach. In the suggestion phase from the DSRM, the requirements for the CCL approach are advocated from the result of the literature review made in the phase of awareness of the problem. Among the activities for organizing the CCL approach are mapping the requirements of the CCL approach, establishing the CCL matching condition, organizing the flow for CCL matching condition, organizing the CCL flowchart, and formulating the CCL algorithm. The CCL approach is a process to prevent the duplication of a digital music file from happening on a personal device from the start of the file being inserted onto the hard disk. This method is achieved by the organization of the CCL approach. The CCL approach is not like any of the digital audio analysis, digital audio synthesizer, digital audio signal processor nor any other researches. It is solely a process of recognizing and learning to store newly-added digital music file. It is also not like any auto-learning system that uses artificial intelligence (AI) techniques, but it is a different / new approach of accepting new feature or not accepting it. With the summarization of the CCL approach conclusion phase, this study ends the presentation on the organization of the CCL approach.

This study models the problem for the current methods, including the solution for the DMAM. Besides that, this study also provides the evaluation based on test cases, which are modeled and the results recorded. For the DMAM, this study adheres to the recommendation from [9], that is to implement object oriented modeling, especially for the data model of an MMDB system. Hence, this study successfully provides the models for the problem, solution, and the evaluation.

4 Analysis of Data

An assessment of the capability of the DMAM is performed and proves that the DMAM is useful as a method to prevent duplication of digital music record from happening on a hard disk of a personal device. A comparative review is conducted to search for approval for the capability of DMAM in preventing duplication of digital music records on a personal device. A total of 83 respondents participated in this comparative review. The instrument used is a questionnaire with four questions, after executing a test using DMAM prototype, and the results of the comparative review are provided here. 78.3% of the respondents accepted that the DMAM capable of preventing duplication of the digital music file on a personal device from the start of the insertion process. 27 respondents selected that DMAM is easy to understand, 32 respondents selected that DMAM need some explanation to use it, and 24 respondents selected that DMAM needs very detail explanations to use it. Meanwhile, 46 respondents selected that DMAM is relevant, 35 respondents selected that some of the DMAM may be not relevant, and only 2 respondents selected that DMAM definitely not relevant. Finally, 70 respondents chose DMAM rather than other software to prevent duplication.

Besides that, a review by focus group activity is also performed, to recover the quality of the developed software and as a complement to testing of other products [46]. This activity is one of the popular techniques used to gather qualitative data through group interaction on a topic determined by the researcher [47]. It is conducted by a number of academicians who have experiences in software engineering, multimedia, or music domains. [48] advised that having between three to five experts participating in a review by focus group is sufficient. For instances, [49] used six experts to review her work, meanwhile, [50] used four experts to review his work. This number is sufficient as supported by [47], [51]–[53]. The procedures for the review by focus group are described here; setting up the review form based on the selected assessment attributes, conducting the review, and analyzing the results. A number of experts have reviewed this research work. The experts are from software engineering, multimedia and music backgrounds. Besides that, the experts do have a higher

education qualification and with an academic background. The experts are from the 36 to 50 years old age group with experience from 10 to 27 years in various ICT and music fields, also some of them are Ph.D. holders and the remaining possesses a minimum of master degrees. The age of the experts varies from 36 to 50 which show the level of maturity in giving opinions and assessments. Hence, it is applicable to the review process. The main instrument used for this review is a questionnaire which contains six questions asking about; Terminologies used for DMAM and CCL approach, Relevancy of the proposed requirements for each component, Problem modeled, Solution modeled, Capability of the DMAM and the CCL approach, and Features of the DMAM. Along with that, few demographic questions are also asked; age, gender, education and field of expertise.

The experts are also encouraged to write their further comments in the provided instrument. For the first question, a list of terminologies is included and the experts are required to verify its clarity (i.e. is easy to understand or needs some explanation or needs very detailed explanations). As for the second question, nine main requirements of the conceptual design model are listed; Human ear, Human brain, Interface, Processor, Storage, Recognition, Learning, Cognitive Learning, and Constructive Learning. The experts are required to verify their relevancy (i.e. all are relevant or some may be not relevant or some are definitely not relevant). For question three to five, the experts are required to validate the items by giving "yes" if they agree with the statement and "no" if vice versa. Question six asks the agreement from the experts about the features of the DMAM, which are Find duplication file, Clean duplication file, Recognize file before inserted, Search storage for similar file before inserting file, Filter file before stored on a personal device, Implement multimedia data modelling, Implement MPEG-7 DSs, Implement audio fingerprinting, Implement content based retrieval, Implement semantically based retrieval, Implement audio classification, and Implement audio object recognition.

Lastly, they are expected to give overall comments based on their understanding and perception of the DMAM and the CCL approach. During the session, the researcher briefly explained the background of the study and the objectives. Then, all the models are introduced. The review session involved two-way interactions, where experts may ask questions and give their opinions on the focused matter. Afterward, the experts are required to answer all the questions in the questionnaire. The results of the review by focus group are obtained; they are clarity of the terminology used, the relevance of the proposed requirements, the problem VS solution, the capability, and the analysis of review by focus group for the features of DMAM. In general, some of the significant findings are; the clarity of the terminologies used is easy to be understood, the relevancies of the proposed requirements are all relevant, the models for representing the problems are relevant, the models for representing the solution are relevant, the DMAM is capable, and finally, the features of the DMAM are fit to deliver the capability of DMAM. So, this review by focus group confirms the DMAM. In another note, the reviewers never use any music manager software to find the duplication music file. The reviewers also never use any duplication cleaner software to clean the duplication music file. All in all, reviewers find that the DMAM and CCL approach provide assistance for the user to store music file without having the problem of duplication to happen. The CCL approach and DMAM are capable of preventing digital music file duplication on a personal device.

5 CONCLUSION

This study concludes that the CCL approach helps to prevent duplication of a digital music file on a personal device. Appropriate requirements are gathered for the new CCL approach in preventing duplication of a digital music file on a personal device and present them successfully. DMAM is designed, developed, and proposed. Consequently, the CCL Algorithm is formulated. Based on the assessment of the CCL approach and the DMAM by the review by focus group, both the new approach and archiving model are validated and verified. The CCL approach has proven to be better than current digital music duplication detection applications.

REFERENCES

[1] M. Harris, "Top 3 duplicate file finders - Free duplicate music file cleaners - Whip your music library back into shape by using a duplicate music file finder," *About.com Digital Music*. [Online]. Available: http://mp3.about.com/od/musiclibrarymaintenance/tp/Free-Duplicate-Music-File-Finders.htm. [Accessed: 07-Apr-2013].

[2] AbeeTech, "Abee MP3 duplicates finder," *AbeeTech*, 2008. [Online]. Available: http://abeetech.com/mp3-duplicates-finder/. [Accessed: 07-Apr-2013].

[3] Hardcoded Software, "dupeGuru music edition," *Hardcoded Software*, 2012. [Online]. Available: http://www.hardcoded.net/dupeguru_me/. [Accessed: 07-Apr-2013].

[4] DigitalVolcano, "Duplicate cleaner - Find duplicate files," 2012. [Online]. Available: http://www.digitalvolcano.co.uk/duplicatecleaner.html. [Accessed: 07-Apr-2013].

[5] "Duplicate music files finder," *LC IBros Solutions*, 2008. [Online]. Available: http://www.lcibrossolutions.com/dmff. [Accessed: 07-Apr-2013].

[6] Steven Mayall, "Musicbee - music manager and player," 2012. [Online]. Available: http://getmusicbee.com/. [Accessed: 07-Apr-2013].

[7] GAR software, "Similarity," *GAR software*, 2013. [Online]. Available: http://www.similarityapp.com/. [Accessed: 07-

Apr-2013].

[8] TuneUp Media, "TuneUp," *TuneUp Media*, 2012. [Online]. Available: http://www.tuneupmedia.com/. [Accessed: 07-Apr-2013].

[9] D. A. Adjeroh and K. C. Nwosu, "Multimedia database management - Requirements and issues," *IEEE Int. Conf. Multimedia.*, vol. 4, no. 3, pp. 24–33, 1997.

[10] W. I. Grosky, "Managing multimedia information in database systems," *Communications of the ACM*, vol. 40, no. 12, pp. 72–80, 01-Dec-1997.

[11] G. Lu and T. Hankinson, "A technique towards automatic audio classification and retrieval," in *International Conference on Signal Processing*, 1998, pp. 1142–1145.

[12] O. Hellmuth, E. Allamanche, T. Kastner, M. Cremer, and W. Hirsch, "Advanced audio identification using MPEG-7 content description," *Audio Eng. Soc.*, pp. 1–12, 2001.

[13] A. Hanjalic, R. Lienhart, W.-Y. Ma, and J. R. Smith, "The holy grail of multimedia information retrieval: So close or yet so far away?," *IEEE*, vol. 96, no. 4, pp. 541–547, Apr. 2008.

[14] Jae-Hoon, C.-S. Cho, and D.-S. Kim, "Design of an interactive object audio system for cloud-based consumer devices," in *ACM Research in Applied Computation Symposium*, 2012, pp. 112–113.

[15] T. Reynolds, "Ear, nose and throat problems in accident and emergency.," *Nurs. Stand.*, vol. 18, no. 26, pp. 47–53, 2004.

[16] M. W. Dubin, *How the brain works?* 2001.

[17] R. C. Atkinson and R. M. Shiffrin, *Human memory: A proposed system and its control process*. 1967.

[18] A. D. Baddeley, *Human memory: Theory and practice*. 1997.

[19] A. D. Baddeley, "The psychology of memory," in *The Essential Handbook of Memory Disorders for Clinicians*, 2004, pp. 1–14.

[20] A. P. Yonelinas, L. J. Otten, K. N. Shaw, and M. D. Rugg, "Separating the brain regions involved in recollection and familiarity in recognition memory.," *J. Neurosci.*, vol. 25, no. 11, pp. 3002–8, Mar. 2005.

[21] A. G. Greenwald, "Cognitive learning, cognitive response to persuasion, and attitude change," in *American Psychological Association symposium*, 1967, pp. 147–169.

[22] D. E. Leidner and M. Fuller, "Improving student learning of conceptual information: GSS supported collaborative learning vs. individual constructive learning," *Decis. Support Syst.*, vol. 20, no. 2, pp. 149–163, 1997.

[23] M. Slaney and R. F. Lyon, *Lyon's cochlear model*. 1988.

[24] E. Grassi and S. A. Shamma, "A biologically inspired, learning, sound localization algorithm," in *Conference on Information Sciences and Systems*, 2001.

[25] E. Grassi, "A learning, biologically-inspired sound localization model," 2000.

[26] L. Turicchia and R. Sarpeshkar, "A bio-inspired companding strategy for spectral enhancement," *IEEE Trans. Speech Audio Process.*, vol. 13, no. 2, pp. 243–253, 2005.

[27] D. W. Graham, "A biologically inspired front end for audio signal processing using programmable analog circuitry," 2006.

[28] M. Elhilali and S. A. Shamma, "A biologically-inspired approach to the cocktail party problem," in *IEEE International Conference on Acoustics, Speech and Signal Processing*, 2006, pp. 637–640.

[29] T. Rodemann, M. Heckmann, F. Joublin, C. Goerick, and B. Scholling, "Real-time sound localization with a binaural head-system using a biologically-inspired cue-triple mapping," in *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2006, pp. 860–865.

[30] P. R. Liu and M. Q.-H. Meng, "A bio-inspired robotic sound localization method," *Int. Conf. Adv. Intell. Mechatronics*, pp. 1–6, 2007.

[31] J. Liu, H. Erwin, and S. Wermter, "Mobile robot broadband sound localisation using a biologically inspired spiking neural network," *Int. Conf. Intell. Robot. Syst.*, pp. 2191–2196, Sep. 2008.

[32] J. Liu, D. Perez-Gonzalez, A. Rees, H. Erwin, and S. Wermter, "A biomimetic spiking neural network of the auditory midbrain for mobile robot sound localisation in reverberant environments," in *International Joint Conference on Neural Networks*, 2009, pp. 648–655.

[33] L. R. Squire, "Memory and brain systems: 1969-2009.," *J. Neurosci.*, vol. 29, no. 41, pp. 12711–6, Oct. 2009.

[34] H. Okano, T. Hirano, and E. Balaban, "Learning and memory," in *National Academy of Sciences*, 2000, vol. 97, no. 23, pp. 12403–12404.

[35] K. H. Pribram, "The cognitive revolution and mind/brain issues.," *Am. Psychol.*, vol. 41, no. 5, pp. 507–20, May 1986.

[36] L. R. Squire, "Memory systems of the brain: a brief history and current perspective," *Neurobiol. Learn. Mem.*, vol. 82, no. 3, pp. 171–7, Nov. 2004.

[37] R. Naataneen, E. Schroger, S. Karakas, M. Tervaniemi, and P. Paavilainen, "Development of a memory trace for a complex sound in the human brain," *Neuroreport*, vol. 4, no. 5, pp. 503–506, 1993.

[38] D. Kuhn, "The application of Piaget's theory of cognitive development to education," *Harv. Educ. Rev.*, vol. 49, no. 3, pp. 340–360, 1979.

[39] P. Gómez-Vilda, J. M. Ferrández-Vicente, V. Rodellar-Biarge, A. Álvarez-Marquina, and L. M. Mazaira-Fernández, "A bio-inspired architecture for cognitive audio," *Lect. Notes Comput. Sci.*, vol. 4527, pp. 132–142, 2007.

[40] S. Lewandowsky, T. J. Palmeri, and M. R. Waldmann, "Introduction to the special section on theory and data in categorization: Integrating computational, behavioral, and cognitive neuroscience approaches.," *J. Exp. Psychol. Learn. Mem. Cogn.*, vol. 38, no. 4, pp. 803–6, Jul. 2012.

[41] R. Parekh, J. Yang, and V. Honavar, "Constructive neural-network learning algorithms for pattern classification.," *IEEE Trans. Neural Networks*, vol. 11, no. 2, pp. 436–51, Jan. 2000.

[42] C. J. C. Burges, "A tutorial on support vector machines for pattern recognition," *Data Min. Knowl. Discov.*, vol. 2, no. 2, pp. 121–167, 1998.

[43] Vijay K. Vaishnavi and W. Kuechler, *Design science research*

methods and patterns innovating information and communication technology. Auerbach Publications, 2007.

[44] A. R. Hevner, S. T. March, J. Park, and S. Ram, "Design science in information systems research," *MIS Q.*, vol. 28, no. 1, pp. 75–105, 2004.

[45] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, "A design science research methodology for information systems research," *J. Manag. Inf. Syst.*, vol. 24, no. 3, pp. 45–77, Dec. 2007.

[46] K. E. Wiegers, "Seven truths about peer reviews," *Cut. IT J.*, vol. 15, no. 7, 2002.

[47] D. L. Morgan, "Focus Groups," *Annu. Rev. Sociol.*, vol. 22, no. 1, pp. 129–152, Aug. 1996.

[48] B. Shneiderman, "Relate–Create–Donate: a teaching/learning philosophy for the cyber-generation," *Comput. Educ.*, vol. 31, no. 1, pp. 25–39, Aug. 1998.

[49] S. M. Sarif, "Conceptual design model of computerized personal-decision aid (ComPDA)," 2011.

[50] S. B. Zaibon, "Mobile game-based learning (mGBL) engineering model," 2011.

[51] E. Folch-Lyon and J. F. Trost, "Conducting Focus Group Sessions," *Stud. Fam. Plann.*, vol. 12, no. 12, p. 443, Dec. 1981.

[52] J. Kitzinger, "Qualitative research. Introducing focus groups.," *BMJ*, vol. 311, no. 7000, pp. 299–302, 1995.

[53] J. Nielsen, "The use and misuse of focus groups," *IEEE Softw.*, vol. 14, no. 1, 1997.

Hammuzamer Irwan bin Hamzah studied for Bachelor of Information Technology with Honors majoring in software engineering at Universiti Utara Malaysia, Kedah, Malaysia. He then obtained his MSc in Real-Time Software Engineering at Centre for Advanced Software Engineering (CASE), UTMKL, Kuala Lumpur, Malaysia. He is currently pursuing his Ph.D. at Universiti Teknologi PETRONAS, Perak, Malaysia. He is now working as Tutor at School of Multimedia Technology and Communication, Universiti Utara Malaysia teaching undergraduate students for more than five years. He teaches courses such as real-time programming, www programming, multimedia database, multimedia networking, software engineering, integrative media, ergonomic, ubiquitous technology, and some more courses.

Low Tan Jung obtained his Bachelor degree in Computer Technology from Teesside University, UK in 1989 and MSc IT from the National University of Malaysia in 2001. He achieved his Ph.D. research in Universiti Teknologi PETRONAS in Underwater Acoustic Communications. He is currently a senior lecturer in Computer and Information Sciences Department, Universiti Teknologi PETRONAS, Perak, Malaysia. He joined UTP in late 2003. Some systems he has developed are like remote monitoring and alerting system for oil pipelines corrosion detection using SMS via GSM network, 3D Spatial Points Detector – using 2 webcams to detect 3D points, an SMS based Q&A system for large conference hall, Sign-to-voice and Voice-to-sign language translator for speech impaired people, Wireless Sensor Network for Water Resource Monitoring & Management, and Wireless sensor Network System for Green IT. Low is currently involved in R&D for extending the Green IT project into green data center applications and dynamic PCs power management to provide a solution for CO2 emission reduction. Low has been in the academic line for more than two decades already mainly as lecturer cum researcher in various public and private institutes of higher learning. He teaches various engineering and ICT courses. His research interests include wireless technology, embedded systems, wireless sensor network, and grid computing.

Ariffin Abdul Mutalib and gained his Ph.D. in Information Technology from Universiti Utara Malaysia in 2009. His has MSc. In Interactive Multimedia from Heriot-Watt University, Scotland, the UK in the year 2001. He obtained his Bachelor in Information Technology from Universiti Utara Malaysia in 1999. He is currently a senior lecturer at the School of Multimedia Technology and Communication, Universiti Utara Malaysia. He is also Deputy Dean there. His expertise is in HCI, User Experience, Usability, eLearning, Web-based application, Emerging Technologies and much more. He teaches courses for undergraduate such as Multimedia Networking, Digital Audio Technology, User-Centered Design, WWW Programming, Ubiquitous and Wearable Computing, Multimedia Seminar, Human-Computer Interaction, and Integrative Media. He also teaches for Graduate student courses such as Information Technology for Managers, Usability Engineering, Research Methodologies, and Information System Management.