Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 184 (2021) 306–313

Procedia Computer Science

www.elsevier.com/locate/procedia

The 12th International Conference on Ambient Systems, Networks and Technologies (ANT)
March 23 - 26, 2021, Warsaw, Poland

Quranic Education and Technology: Reinforcement learning System for Non-Native Arabic Children

Bayan M. Alsharbi*, Omar Mubin, Mauricio Novoa

Western Sydney University, Sydney, Australia, 2150

Abstract

We built a simulator based on reinforcement learning to improve teaching experience in Quranic and Islamic education for non-native Arabic speakers to evaluate their strength and weaknesses and allow the system to help improving the child in one hand, and provide an accurate actual report for each child on the other hand.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Outletset; Outlet; Nooraniah Qaidah; Reinforcement Learning;

1. Introduction

Most religions practiced at present are grounded in deep history and tradition. Sculptures and writings have been passed on from generations and are such integral to the sanctity of the religion. Islam is one of the largest religions in the world with almost 1/5th of the world's population being of Muslim faith [12]. Since the birth of the religion took place in Saudi Arabia of today, most rituals, teachings and practice related to Islam is done in the Arabic language. Although, the holy book of Islam: The Quran is translated in many languages it is always read in Arabic as a matter of principle and custom. A common myth regarding Muslims is that they all can speak Arabic - current estimates indicate that only 20% of Muslims speak Arabic as their first language [20]. Hence many Muslims in non-Arabic environments either rely on rote learning of Arabic verses within the Quran without a focus on proper pronunciation and dialect, especially in younger children. This is particularly a dilemma if Arabic instructors are not available, as correct recitation of the Quran is imperative as a matter of principle [17]. Traditionally all forms of Islamic teaching in the Muslim world, particularly learning and reading of the Quran and praying begins from young ages (as little

* Corresponding author. Tel.: +61-450059590
E-mail address: 18516887@student.westernsydney.edu.au

1877-0509 © 2021 The Authors. Published by Elsevier B.V.

Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2021.04.007

as 7 years old), therefore it is imperative to enhance and facilitate the learning experience of children. Additionally reading and understanding Quran forms an integral part of a Muslim's belief and as such many continue the learning process well into adulthood [1]. Currently, most Islamic education takes places in either dedicated religious schools (Madrassahs or mosques, headed by sheikhs or religious scholars as extra-curricular after school or weekend classes), in Islamic specialized private schools, or at home by either parents or co-located religious scholars [3].

In summary, we would like to list the significant design implications for Quranic education that have emerged from our discussions with primary school teachers and religious scholars.

1. Supplement proposed technology with human instruction and automatic speech recognition of Arabic should be cautiously incorporated
2. A reward mechanism is vital to not only motivate children but also allow them to monitor their progress; particularly for children whose first language is not Arabic
3. The proposed technology should demand and allow parents to play a key role in the Quranic education of their children
4. The credibility and authenticity of the proposed technology for Quranic education should be transparent and easily attainable
5. The proposed technology should cater for both individual and group based Quranic education
6. The proposed technology should allow the instructors to have a direct link with the developers so that any errors in the scripture or interaction can be rectified

In this paper, we built a simulator based on reinforcement learning. The main focus is Quranic and Islamic education to non-native Arabic children. The proposed system is built to improve teaching experience for both teachers and students. Such that, a teacher can easily monitor the child progress and obtain a report stating the actual strength and weaknesses. While the child may use the unity 3D self practise website or use the virtual class, where teachers are involved in the learning system and reinforcement learning is backbone of the system. Clearly, we improve teaching experience by evaluating children's knowledge in large collaborative class using reinforcement learning, to improve children's learning experience in Quranic and Islamic Education. Providing a system deals with children with no prior knowledge about their background and mother language in Quranic education is a challenge where special difficulty come to teachers to evaluate children in a large class size.

Thus, the built simulator helps teachers to assess their students regardless the class size, and help students to get improved in Quranic education regardless their background or weaknesses. Indeed, we investigate the problem of maximizing the system utility to investigate the children strength and weaknesses and finally provide accurate real time record for teachers, where the system is capable to suggest levels based on the child outcome and help in improving.

2. Related Works

The use of digital technology can provide us with a mechanism to not only maintain the consistency of the teachings of religion but also establish a real time learning and understanding process for a variety of users. With the growth in use of smart phones, mobile apps are now being utilised in the teaching of religion [24]. A seminal overview [6] of such apps showed that search terms related to Islam and Christianity resulted in more than 3000 hits on iTunes. This clearly shows that there is a wide interest and endeavour in learning religions and disseminating information about religions through mobile apps and web-based. Furthermore, the same review showed that the common themes of such apps were related to religious content, rituals and practices - although it is not immediately clear how many were directly linked to teaching Quran or how many were being used as part of the official curriculum in either Madrassah's or Islamic schools.

State of the art research shows that there is recent intersection of Islam and technology. In today's age of multimedia and ICT, a number of research ventures are being undertaken to promote learning and reading of the Quran through digitisation - one overview being [27]. Interfaces employed to teach Arabic and consequently Quran extend beyond web and mobile platforms, with games and interactive systems also used [14] although such ventures are few and far in between [2, 26]. Advancements in Arabic speech recognition have allowed checks and verification of Tajweed [19];

i.e. pronunciation of verses from the Quran [21, 7]. Slowly in schools, colleges and universities based in the Muslim world, Islamic education is supplemented with novel forms of technology [16, 13]. We can observe the proliferation of mobile apps in the developing world and the uptake of the same to teach languages [11] such as Arabic [10], where emerging technologies are utilised to learn words and expression in second languages. It is contemplated that mobile versions of the Quran can provide portability and accessibility in comparison to the physical copy of Quran. Therefore, we believe therein lies great potential in utilising mobile and computing technology to promote Quranic education [17] leveraging from the possibility of providing interactivity and profiling to the students. As mentioned prior varying levels of technology are being employed in the aforementioned setups within Islamic and Quranic education, however, the penetration, role and acceptance of mobile or advanced technology in such settings is relatively unclear. In particular, the study of religion and its open intermingling with technology is a sensitive debate [5], particularly the combination between Islam and technology [18] as there is a threat of unintentional errors being introduced in the interaction, thereby compromising the sanctity of the religious script. It is also not immediately transparent or realized whether religious scholars or Islamic school teachers are involved in the design of the technology for Quranic education. Ideally, the developmental process of technology for Islamic Education should involve religious scholars and/or Islamic school teachers as the importance of accreditation and standardisation of digital Quranic solutions has been highlighted [27]. Involving religious experts and recognised Islamic scholars in the technology creation process as a trust building mechanism via a user-centered design process will also ultimately address the issues of acceptance and pessimistic attitudes [22] towards the intermingling of Islam and technology. Our long term goal is to provide and promote user-centered technological solutions for reading Quran in Islamic institutions with a focus on not only improving the learning experience of children and students but also assisting the scholars and teachers in managing the learning process. It is commonly acknowledged that most digital solutions used to learn and read the Quran are tailored to Arabic speakers [8] and that non Arabic speaking users may find it difficult to interpret the deeper (contextual) meanings of the Holy Quran [4]. Research from other religions also indicates that providing multilingual support to students of a religion is imperative [23].

In sum, to the best of our knowledge we believe our study is one of the first to explore the potential of technology for Quranic Education through qualitative discussions with two groups of instructors, namely school teachers and religious scholars, despite the fact that reinforcement learning has not been used for such purposes.

3. Methodology and Approach

In terms of specifying that the research for the dissertation considers the user centered design and it will combine both quantitative and qualitative methods collaboratively to collect data from teachers and scholars. From the quantitative, the main goal is to consider the design implication while from the qualitative study the actual mosque classes problem and challenges are taken into consideration.

Furthermore, user-centered design approach will be applied in our methodology such that a user research phase and user evaluation phase are the main stage . User research phase will be used to feed the system, gather and finds the requirements to be implemented while in the user evaluation phase will use the user to evaluate the system and ensure its satisfaction for the requirements. Fig. 1 shows the model of user-centered design such that it begins with analysis, followed by the design, then to evaluation and ends up with the implementation. The gray arrows indicate that more than one round takes place to evaluate and finalize the system.

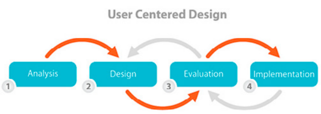

Fig. 1: User Centered Design

Based on our findings from both group of instructors, teachers and scholars, we are going to build a reinforcement learning system, since we have no prior knowledge about the target group of children, their background, strengths, and difficulties.

The designed simulator, builds knowledge about children before start interacting with them and become actually able to provide maps of practise which satisfy the needs of each child.

The system deals with the 'Nooraniah Qaidah' and its lessons. such that each lesson in one map, and each map consists of 'OutletSet', which consists of about 28 'Outlet'.

3.1. System Model

Fig. 2 shows the system model from the child and the teacher prospective. It consists of three main blocks, namely, user diagram, login screen diagram and virtual class or reinforcement learning diagram.

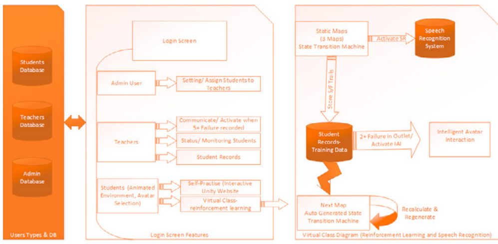

Fig. 2: System Overview

- User Types & DB: Three types of users admin, students and teachers.
- Login Screen Features: Each type of user may perform set of tasks as follows:

  1. (Admin) is to set up the environment required and assign students to teachers.
  2. (Teacher) is to directly communicate with the child whenever help needed or violate n number of pronunciation failure in the same Outlet. (Teacher) is to check students status and monitoring students. (Teacher) is to find the students record.
  3. (Student) is to select an avatar for the virtual environment. The child can either choose to self-practise system or to choose a virtual classroom where teachers are involved.

- Virtual Class/Reinforcement Learning Diagram: There is three static maps based on state transition machine build via reinforcement learning along with speech recognition system. These maps are the first three lessons out of the 'Nooraniah Qaidah'. Since there is no training data, state transition machine will build training database for each student based on the probability distribution from the state transition machines. After 3 maps finished, the next maps (up to 15 maps) will be dynamically generated based on reinforcement learning and its dictionary. The student will hear the phrase or outlet then try pronounce it. 2 failures will activate the intelligent avatar movement.This is called Try and Error Mechanism, where the reward and punishment of the system are either coins or failure.

Each lesson in the Nooraniah Qaidah is represented in a map. Each map represented as an state transition machine as shown in Fig. 3. The first three maps, is used to build some knowledge about children before the fourth map is dynamically generated based on the participant's strength and weaknesses and the probability distribution which will be explained in the next section. Every state machine has a starting point and terminal state or final state.

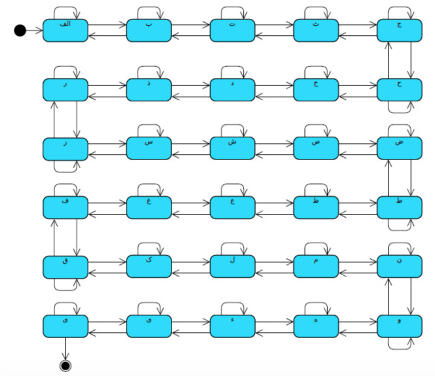

Fig. 3: State Transition Machine for the First Map

3.2. Reinforcement Learning Model

Reinforcement learning based system has been widely used in education [15, 25], however, to the best of our knowledge, this is the first research use reinforcement learning for evaluating Non-native Arabic Children for Quranic education. Fig. 4 shows a part of the state machine we generate, for each map in the learning system. In this state machine, there is a state corresponding to each WORD/outlet in the learning system. Each map contains a starting state and ending state. A speech recognition system is activated and responsible for reward and punishment.

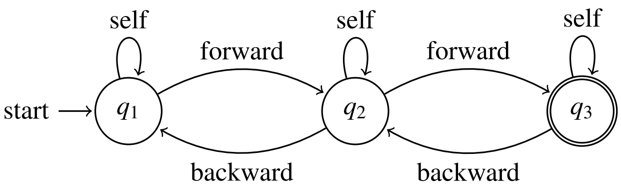

Fig. 4: Part of the State Transition Machine

Here are the notations we used in this paper:

- q: is a state in the state machine which is corresponding to a WORD in the map
- t: from 0 to T The number of times a child needs to pronounce 1 Char
- $r_t(q)$: amount of reward obtained by the student at time t and state q
- α is a constant value to adjust the computation of the average rewards
- $Q_t(q, a)$: A value we assign to action a at time t in state q.
- $\pi_t(a)$: the probability of choosing action a at time t.
- β is a constant value to adjust the computation of action values

The amount reward is set to each state of the machine. The initial value of this reward is set to zero and then it is reinforced based on the answers received from the student. The student's answer is the result of child's pronunciation obtained from the ofypeech recognition system. More specifically, the reward is positive if the student's answer is correct, and the reward is negative if the student's answer is incorrect. Here is the formula for this computation:

$$r_t(q) = \begin{cases} c, & \text{for answer}(t) = True \\ -1 \times c, & \text{for answer}(t) = False \end{cases} \quad (1)$$

where c is constant value set by the system administrator, and answer(t) is a function for defining the result of pronunciation question asked from the student at time t. The output of the answer(t) is $True$ if the student pronounces the word correctly at time t and the output of the answer(t) is $False$ if the student pronounces the word incorrectly at time t. So, we have: $r_t(q) = 0 \quad \text{for } t = 0$.

$$\text{answer}(t) = \begin{cases} True, & \text{student's answer is correct} \\ False, & \text{student's answer is incorrect} \end{cases} \tag{2}$$

We compute the average reward for each state according to the answers obtained from the student. Here is the computation for the average reward at time t:

$$\bar{r}_{t+1}(q) = \bar{r}_t(q) + \alpha[r_t(q) - \bar{r}_t(q)], \quad when \quad \bar{r}_t(q) = 0, \quad \text{for } t = 0 \tag{3}$$

where r_t is the reward obtained at time t and $\bar{r}_t$ is the average reward obtained at time t using Eq. (3) at the previous time. It is to be noted that r_t is directly obtained from the correctness of the child's answer.

Now we update the action value for every possible action we have at the current state. It is to be noted that we force student to stay at the current state for the first three iterations. During the first three iterations, the student only earn the rewards according his/her answers to the questions. Thus, we update the action value in the way that the student force to stay in the current state, and accordingly choose the action *self*. Thus, we suggest the following computations for the action values in the first three iterations:

$$Q_t(q, a = self) = 1 \quad \text{for } t = 1, 2, 3 \tag{4}$$
$$Q_t(q, a = forward) = 0 \quad \text{for } t = 1, 2, 3 \tag{5}$$
$$Q_t(q, a = backward) = 0 \quad \text{for } t = 1, 2, 3 \tag{6}$$

After the third iterations, we employ a randomised mechanism to choose the next state according to the action value. Thus the action values after the third iterations are computed based on both the average reward and the answer from the student. Here are the computations:

$$Q_t(q, a = forward \mid \text{answer}(t) = True) = \bar{r}_t(q) + \beta[r_t(q) - \bar{r}_t(q)] \tag{7}$$
$$Q_t(q, a = self \mid \text{answer}(t) = True) = \bar{r}_t(q) - \beta[r_t(q) - \bar{r}_t(q)] \tag{8}$$
$$Q_t(q, a = backward \mid \text{answer}(t) = True) = \bar{r}_t(q) - \beta[r_t(q) - \bar{r}_t(q)] \tag{9}$$
$$Q_t(q, a = forward \mid \text{answer}(t) = False) = \bar{r}_t(q) - \beta[r_t(q) - \bar{r}_t(q)] \tag{10}$$
$$Q_t(q, a = self \mid \text{answer}(t) = False) = \bar{r}_t(q) + \beta[r_t(q) - \bar{r}_t(q)] \tag{11}$$
$$Q_t(q, a = backward \mid \text{answer}(t) = False) = \bar{r}_t(q) + \beta[r_t(q) - \bar{r}_t(q)] \tag{12}$$

The probability of choosing an action a can be directly obtained from the actions' values. A very useful technique for this computation is using softmax formula where n is the number of possible action to be chosen, as follows:

$$\pi_t(q, a) = Pr[q, a_t = a] = \frac{e^{Q_t(q,a)}}{\sum_{b=1}^{n} e^{Q_t(q,b)}} \tag{13}$$

3.3. *The softmax function*

The softmax function [9] takes as input a vector z of K real numbers, and normalizes it into a probability distribution consisting of K probabilities proportional to the exponential of the input numbers. That is, prior to applying softmax, some vector components could be negative, or greater than one; and might not sum to 1; but after applying softmax, each component will be in the interval (0,1), and the components will add up to 1, so that they can be interpreted as probabilities. Furthermore, the larger input components will correspond to larger probabilities. The standard (unit) softmax function $\sigma : \mathbb{R}^K \to \mathbb{R}^K$ is defined by the formula:

$$\sigma(\mathbf{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}} \text{ for } i = 1, \ldots, K \text{ and } \mathbf{z} = (z_1, \ldots, z_K) \in \mathbb{R}^K \tag{14}$$

It states that we need to apply a standard exponential function to each action value, and then normalize these values by dividing by the sum of all the exponential. Doing so ensures the sum of all exponential values adds up to 1. Fig. 5 provides a useful example to show how the softmax function works.

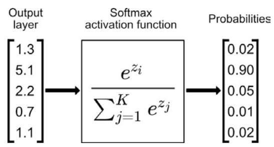

Fig. 5: A example of the Softmax function

4. Demonstration

When a student login to the system, an avatar selection page appears to allow the student to choose before the avatar animated and walked in to the classroom. A pop up computer screen will show up with two options namely, self practise, and virtual class. Self practise will redirect to the Unity 3D website which handle Quranic and Islamic education where Unity 3D has been involved in such an implementation. Virtual class will redirect to the first map. Three maps has been implemented statically, while the fourth and onward maps will be dynamically generated which means different student will get a different map generated based on the system suggestion and the student strength and weaknesses. On top of the page of each map, there is the indication on which outlet to be completed, coins collected on successful trails, and failure rate based on failed trails. Fig. 6 Shows the avatar selection page, student screen when the avatar sit down in the class, self practise page, a map in the virtual class, and teacher screen and its features.

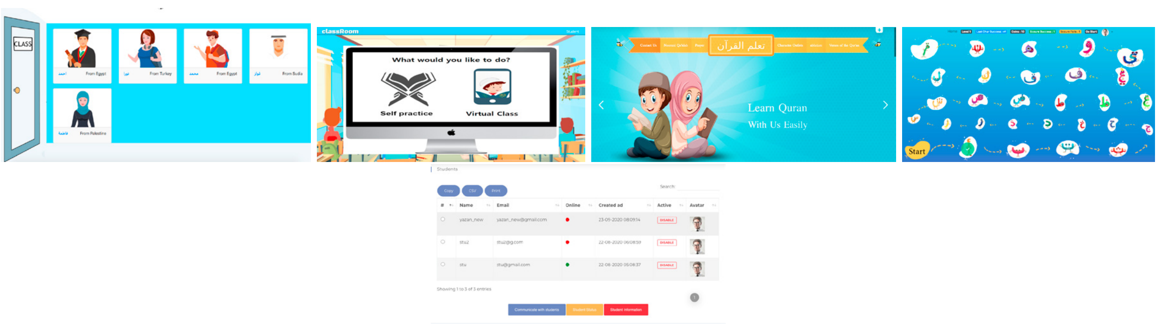

Fig. 6: Avatar Selection Page, Student's Screen, Unity 3D Website(Self Practise), Virtual Class (Map 1), and Teacher Screen

5. Conclusion and Future Work

We have build a simulator and enhance it with a reinforcement learning model to improve teaching experience and meant for Quranic and Islamic education for Non-Native Arabic children. On one hand, the system focus on evaluating children, able to suggest dictionaries to improve the child child learning.One the other hand, teachers are able to interact, communicate, and obtain actual report for each child regardless the class size. In future work, we will show the system to scholars and teachers and receive their feedback in multiple rounds before enhancing the system.

References

[1] Ahmad, N.A., Zainal, A., Kahar, S., Hassan, M.A.A., Setik, R., 2016. Exploring the needs of older adult users for spiritual mobile applications. Journal of Theoretical and Applied Information Technology 88, 154.
[2] Al-Sa'di, A., Parry, D., Carter, P., 2014. Usability considerations for educational tablet applications using an arabic interface, in: Information and Communication Systems (ICICS), 2014 5th International Conference on, IEEE. pp. 1–6.
[3] Anzar, U., 2003. Islamic education: A brief history of madrassas with comments on curricula and current pedagogical practices. Paper for the University of Vermont, Environmental Programme .
[4] Atwell, E., Brierley, C., Dukes, K., Sawalha, M., Sharaf, A.B., 2011. An artificial intelligence approach to arabic and islamic content on the internet, in: Proceedings of NITS 3rd National Information Technology Symposium, Leeds. pp. 1–8.
[5] Biri, K., 2015. Religion and emerging technologies in zimbabwe: Contesting for space? International Open and Distance Learning Journal 1.
[6] Campbell, H.A., Altenhofen, B., Bellar, W., Cho, K.J., 2014. There's a religious app for that! a framework for studying religious mobile applications. Mobile Media & Communication 2, 154–172.
[7] Elhadj, Y.O.M., 2010. E-halagat: An e-learning system for teaching the holy quran. TOJET: The Turkish Online Journal of Educational Technology 9.
[8] Elsayess, M., Hamada, S.E., 2013. Using mobile application in teaching correct recitation of the holy quran, in: 2013 Taibah University International Conference on Advances in Information Technology for the Holy Quran and Its Sciences, IEEE. pp. 535–551.
[9] Gao, B., Pavel, L., 2017. On the properties of the softmax function with application in game theory and reinforcement learning. arXiv preprint arXiv:1704.00805 .
[10] Gharawi, M.A., Bidin, A., 2016. Computer assisted language learning for learning arabic as a second language in malaysia: Teacher perceptions. International Journal of Information and Education Technology 6, 633.
[11] Godwin-Jones, R., 2011. Emerging technologies: Mobile apps for language learning. Language Learning & Technology 15, 2–11.
[12] Hackett, C., Connor, P., Stonawski, M., Skirbekk, V., Potancoková, M., Abel, G., 2015. The future of world religions: Population growth projections, 2010-2050. Washington, DC, Pew Research Center .
[13] Hamzah, M., Ismail, A., Embi, M., 2009. The impact of technology change in malaysian smart schools on islamic education teachers and students. International Journal of Human and Social Sciences 4, 824–836.
[14] Hussain, A., Jomhari, N., Kamal, F.M., Mohamad, N., 2014. mfakih: Modelling mobile learning game to recite quran for deaf children. International Journal on Islamic Applications in Computer Science And Technology 2.
[15] Iglesias, A., Martínez, P., Aler, R., Fernández, F., 2009. Learning teaching strategies in an adaptive and intelligent educational system through reinforcement learning. Applied Intelligence 31, 89–106.
[16] Jusoh, W.N.H.W., Jusoff, K., 2009. Using multimedia in teaching islamic studies. Journal of Media and Communication Studies 1, 86.
[17] Kamarudin, N., Salam, S., 2012. Tajweed understanding among malaysian muslim (a preliminary findings), in: Proc. 1st International Conference on Mobile Learning, Applications and Services (Mobilecase2012), Kuala Lumpur, 2012, pp. 1–4.
[18] Khan, M.K., Alginahi, Y.M., 2013. The holy quran digitization: Challenges and concerns. Life Science Journal 10, 156–164.
[19] Khir, M., Adibah, N., Mustaffa, W., Arif, W., Zulkiflee, Z., Husein, M., Dahlan, A., Rahman, A., 2016. itajweed to enhance the interactive learning modules for the users. International Journal of Computer Science and Information Technology Research 4, 281–291.
[20] Mohammed, K., 2005. Assessing english translations of the qur'an. Middle East Quarterly .
[21] Muhammad, A., ul Qayyum, Z., Tanveer, S., Martinez-Enriquez, A., Syed, A.Z., 2012. E-hafiz: Intelligent system to help muslims in recitation and memorization of quran. Life Science Journal 9, 534–541.
[22] Nasiri, M., Azkia, M., Mahdavi, S.M.S., 2016. Technology and muslims: A field study of iranian scholars. Zygon® 51, 883–903.
[23] Openjuru, G.L., Lyster, E., 2007. Christianity and rural community literacy practices in uganda. Journal of Research in reading 30, 97–112.
[24] Rinker, C.H., Roof, J., Harvey, E., Bailey, E., Embler, H., 2016. Religious apps for smartphones and tablets: Transforming religious authority and the nature of religion. Interdisciplinary Journal of Research on Religion 12.
[25] Shawky, D., Badawi, A., 2018. A reinforcement learning-based adaptive learning system, in: International Conference on Advanced Machine Learning Technologies and Applications, Springer. pp. 221–231.
[26] Shoukry, L., Sturm, C., Galal-Edeen, G.H., 2015. Pre-mega: a proposed framework for the design and evaluation of preschoolers' mobile educational games, in: Innovations and Advances in Computing, Informatics, Systems Sciences, Networking and Engineering. Springer, pp. 385–390.
[27] Zakariah, M., Khan, M.K., Tayan, O., Salah, K., 2017. Digital quran computing: Review, classification, and trend analysis. Arabian Journal for Science and Engineering , 1–26.