International Journal on Emerging Technologies 11(5): 226-233(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Smart Mirror to Enhance Learning: A Literature Review

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(Received 27 June 2020, Revised 30 July 2020, Accepted 20 August 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: This paper describes the work and application of Smart mirrors that were built using Raspberry Pi to enhance learning. A smart mirror can act as a personal assistant and notice board for learning activities. Smart mirror can show weather, date, time, and also update of news. To increase interaction with the mirror user can be equipped with a face recognition and voice control feature. Smart mirrors can be used to display class schedules and information that support the learning process. The screen will be turning on if the user stands in front of the mirror. When the user leaves the mirror, the screen will be turned off. It can happen because smart mirror has a camera to detect objects. Smart mirror includes camera, microphone, Raspberry Pi as the main controller, and LED display that is placed behind the mirror. With that, this certainly can be an innovative way to improve the learning way in the future. This research successfully conducted a literature review on the creation and implementation of smart mirrors that can connect with Raspberry Pi to enhance learning process. One of the challenges in this research is to identify the manufacture and application of smart mirrors and to see the advantages and disadvantages of smart mirrors as a whole. This research is expected to have a contribution to find out in detail the application of the use of smart mirrors in everyday life to improve learning so that it becomes a means to help human work. This study also considers the problem of increasing user profile and experience on smart mirrors.

Keywords: Smart Mirror, Enhance Learning.

I. INTRODUCTION

In the Industrial Revolution 4.0, technology is the key for every industry and business and it develops very rapidly. The development of information and communication technology has a significant influence on the progress of human life. This influence is felt by humans when they want to fulfill their daily needs. Various kinds of human activities have now been assisted by technology, especially automatic machinery. Technological progress is something that cannot be avoided because technological progress will go according to time and also scientific progress. Every technological development will make new innovation in various forms. Every innovation is created to have an impact on human life. Innovation is created to help humans in their work. Moreover, innovation is created to make easier way for humans to live their daily lives. This development has led to many new technological innovations, such as Artificial Intelligence (AI), Augmented-Virtual Reality (AR/VR), and Internet of Things (IoT). This paper will specifically explain IoT technology. IoT is a system of interrelated computing devices, mechanical and digital machines, objects or people that are provided with unique identifiers and ability to transfer data over a network without human-to-human or human-to-computer interaction. The point is, IoT is a concept that an object has the ability to transferring data over a network without human interaction. It will help people's daily life and make life easier. Element in IoT such as sensor, connectivity and small various device is important in the running of the machine. Today, there are so many implementations of IoT. One example of the implementation is the Smart Mirror [15].

Smart Mirror is a technology that combines mirror and monitor to display information. The purpose of this paper is to implement the combination of mirrors with intelligence and technology to improve the learning process. Smart Mirror enables interaction between smart mirror and humans by displaying information that is useful for humans in carrying out their duties without having to interact directly with the computer. The mirror works with Raspberry Pi to make the appearance and information to be displayed. Raspberry Pi is a single-board circuit that can be used to running office program, computer game, until media player with high resolution. The learning process is very important and requires encouragement or help to do well. This product can be a solution to the problem above by working as an interactive, innovative, and interesting tool that can help users improve their learning process. Smart Mirror will help users to install schedules and activities that will be undertaken so that the schedule will be remembered and structured. With this, it is hoped that forgetfulness and delays can be anticipated. So, users can live easier and feel helped by this technology [2, 3].

This research has a gap because previous research only focuses on systems from smart mirrors while this paper focuses on user experience that measured all the time because the mirror provides various information needed. This gap aims to make smart mirrors have a high usability value, and it is hoped that smart mirrors can be applied to help and overcome problems that exist in human life. The value of this Smart Mirror is to assist in a series of daily routines to improve the learning process. In addition to displaying the date, time, weather, and other information, a smart mirror can be a

reminder that will remind users of the updated schedule they have from their calendar [20]. So, users will remember the schedule that they must do. The application of these features can be made by using face recognition or voice control. With these features, it will be easier to detect the right users so the smart mirror can display information that matches the users. Smart Mirror will check every user. If user's data is not listed in the database of the smart mirror, then user cannot access the smart mirror. These features also can secure user's data, so the data cannot be accessed by other people that are not worth to accessing it. The security is guaranteed [5, 6].

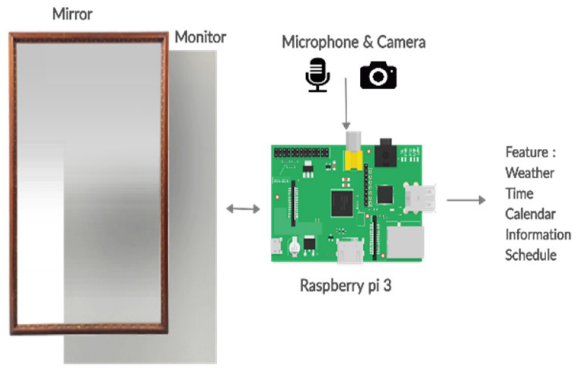

Fig. 1. Smart Mirror design and architecture.

Moreover, a smart mirror can be used as an assistant for students in the academic field. The mirror can act as a personal user assistant that will help a user's learning process. The mirror will perform various tasks, such as display calendars, given reminders, displaying user task lists, approved dates and times, displaying finances, information, and schedule of activities. It can also ask the user about the tasks, whether they want to do or deny carrying out daily tasks [7, 8].

In addition, the personal assistant can be visualized as a human with an appearance that can be customized by the user or any other visual-appearance. With this method, Smart Mirror will become more interactive, and the information can be delivered interactively. It is hoped that users will be more comfortable and feel helped with this "assistant" [1].

To enhance learning, smart mirrors can be used to display various academic information. By displaying the information on the mirror, it will make it easier for users to access the information. This product is connected to the administrator device, it can make and change the information. Approval will correspond to various time slots [2].

The next part of this paper is arranged in the following order: Section II "Methodology" discusses the method that authors used to do the research and the methodology usually used to do smart mirror research, section III "System Design" discusses the design of the system used for build smart mirror to enhance learning, section IV "Advantage and Disadvantage" discusses the advantage and disadvantage of the system used to build this smart mirror, and last, section V "Conclusions" discusses the conclusions of the authors and suggestions for the future research.

II. METHODOLOGY

This section discusses the method chosen to complete this project. The author looks for various kinds of references related to smart mirrors, then filters the references that have been collected to select references that are relevant and by the purpose of this paper. The search process is carried out by searching for appropriate keywords and filtration is done by looking at the discussion topics from each reference and selecting which can be used for the process of using Smart Mirror to enhance learning. After filtration, authors start to create ideas and designs from smart mirrors that can help the learning process. Smart mirrors are created by combining ideas from the collected references and applying them according to the purpose of this paper.

The approach of the methodology used in smartest mirror project is called The Evolutionary Prototyping that collects feedback from users so it can be modified easily. [4, 11-13]. The viewpoint that usually concentrated on is the issue related explanation about the current circumstance, after investigating the issue. In this case, it is to enhance learning. The researcher settled on the goal to be accomplished and the huge of this task for the user. The examination was additionally directed to decide the extent of the user appropriate for the utilization of the smart mirror. Other than that, products and equipment for the smart mirror were additionally investigated in guaranteeing roughly applied in the plan and advancement. Hardly any examinations have been done around there. By including advances in smart mirror, various assignments can be done faster. With headways in Internet of Things and its applications, the mirror is structured to such an extent that the inhabitants can access some information while enhancing the user profile and experience [9,11,10]. Face recognition can be used to detect who is accessing it and will display the information as requested. If the user is not listed in the machine's database, display will not turn on. With this, it is hoped that the safety of the smart mirror will be guaranteed, because only right user will can access this machine. Besides face recognition feature, smart mirror also has voice recognition feature. Voice recognition will help user to run smart mirror and make user's life easier. This can be happening because user can open any feature in this smart mirror only with his or her voice. After receiving the audio, smart mirror will check the database. If the command matches with the database, then smart mirror will run according to the command that requested by the user. Otherwise, it will not run until user use the right command.

III. SYSTEM DESIGN

This paper will discuss how to implement smart mirror to improve learning. Various types of features can be incorporated into a smart mirror. In general, smart mirror functions to be a personal assistant and notice board for users. Fig. 2 shows the flowchart of smart mirror activities, from detection user's motion until executing the task.

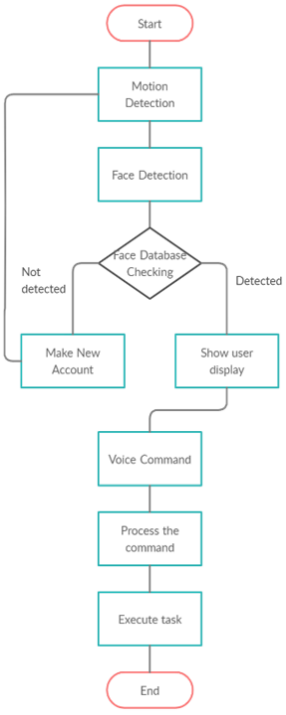

Fig. 2. Flowchart of Smart Mirror.

A. Hardware Design

The initial step was getting the design and all hardware equipment needed to build up smart mirror. Features and locations to be included in the system were resolved for the interface. The frame design was additionally directed to set the casing properly with a screen display to display the data, two-way mirror to act as normal mirror for user, and controller to process the data. It was arranged for enhancing user experience and convenience [14, 15].

Paper [13, 29], discusses about the designs that is usually used to build a raspberry pi based smart mirror. Paper [13] focuses on physical design of smart mirror, features that can be added to smart mirror, and how to implement these feature to smart mirror. Meanwhile, paper [29] focuses on the hardware circuit system for smart mirror. This circuit system is quite important and need to be considered when creating electronic devices, including smart mirror. This is because the circuit on electronic device have an effect on the durability of the device. It needs a well-designed circuit so the device can last for a long time.

In this paper, authors will be more focused on the Raspberry Pi based smart mirror, because the controller that is usually used for making smart mirrors is the Raspberry Pi. This is happening because the controller on the Smart Mirror will be used to process every kind of data, starting from the data about the user that will be displayed on the display screen, data about the user's identity that will be received through the camera to carry out the user verification process, until the data about the commands requested by the user with their voice which will be received through the microphone. The controller on the smart mirror requires a large enough capacity and capability to process all of this data. So, Raspberry Pi is more often used because it has more capacity and capabilities than other controllers.

A two-way reflection is a mirror that is intelligent just as straightforward. This is one of the fundamental pieces of the Smart Mirror and fills in as the UI for the client to associate with [2, 14, 1]. Two way reflects enables mirror from one side to be intelligent and straightforward from another side. Two way reflects made from thin and nearly straightforward metal layer glass [14]. The effect of this activity is that some light is reflected while the rest will invade the glass. It associated with the TV screen inside the two-way reflect, demands the worker side for the client's data, and wanted administrations for show. The client can see himself/herself through the smart mirror's normal mirror usefulness. The client can at present view the profile according to the proposed framework. The client likewise can see the entirety of the administrations (or gadgets) accessible to show on the smart mirror [10].

The camera is required to identify the correct user, and this can be done with collaboration camera and Raspberry Pi [15]. Camera will help the machine to detect existing objects in front of the mirror. If the user stands in front of smart mirror, the machine will run and capture the picture of the user that used the smart mirror [17, 18, 3]. If the user is not listed in the database of the machine, machine cannot detect him or her and unable to run and display anything. The security of this machine is guaranteed. The display captured by the camera will also be processed by a machine, so there is no left-right confusion, and the display can be adjusted by users, the machine can display a mirrored display or normal display [13, 19]. The Raspberry Pi 2 has no input for microphone, so an external USB microphone is needed [2, 1, 8]**.** The microphone will be used to detect the voice of the user and process the data, so smart mirror can do the task according to the request of the user. With this feature, the user can manage the mirror easily. If voice or audio that user said is not available in the database, then smart mirror will do nothing. But, if voice that user said match with the database, then smart mirror will do exactly what user want. The machine will do the task according to the command given and respond using speakers. Speakers will also remind the user with an alarm or notification if there is a schedule or any activities [15]. It will be able to remind and help the user for manage the upcoming schedule. It is hoped that forgetfulness and delays can be anticipated.

The Raspberry Pi is the fundamental segment of the framework. All different gadgets are associated with this segment. The block diagram for the proposed model shows details. The Mirror State is a synchronization unit. The fundamental undertaking of this product segment is to give synchronization among all the segments associated with the Raspberry Pi. All the orders that are given to the Raspberry Pi are first passed to the Mirror State. Mirror State deciphers the orders gave to the framework. The model structure of crafted by advanced Intelligent Mirror improvement will be associated with Raspberry Pi 3 for the encompassing home condition just as business utilizes in different types of industry. Individuals have a mirror at home, so the idea of savvy reflects that you can connect with is

interesting and can be fantasized by anybody nobody has the opportunity to peruse the paper or switch the TV directly in the first part of the day to check the updates on the title text or climate figure. If mirrors work for this reason, one can envision the measure of time it will spare and become excellent use [1, 12, 20].

Relay switch is a switch controlled from raspberry pi that directly connected to the raspberry pi. Basically, relay switch works by receiving low and high voltage from raspberry pi, this received voltage will turn on and off the switch. This function can be used by utilizing the GPIO pins available on the raspberry pi. By using relay switch, the non-smart devices only need to be connected to raspberry pi. This switch is usually used to control non-smart devices; such as lights or speaker. In this smart mirror, these switch will act as an addition that will be added if the user want to add lights or speaker that connected to the smart mirror and can be controlled from the smart mirror [25].

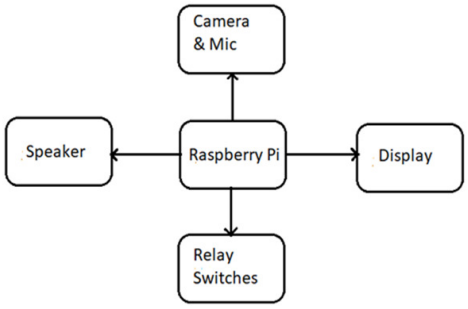

Fig. 3. System Block Design.

B. Software Design

When the hardware has been readied, Raspberry Pi was utilized, which is the fundamental concentration in building up the highlights for the smart mirror. The raspberry working framework was utilized to introduce specific modules. The programming language was used to edit the features and to make it compatible with the systems after getting the modules [21, 22].

This framework will begin when there is a presence or movement in front of the mirror. It will identify the movement; the Smart Mirror will turn ON when there is movement. In any case, if inverse it will stay OFF. The client will choose any highlights that longing, at that point the framework will work through the SPI that will figure out how to show the highlights [26]. The PIR sensors are utilized for movement recognition. At the point when the movement is detected, the Mirror State actuates Raspberry Pi which thus triggers the camera. Presently camera takes up the video. The video will be changed over into outlines. Movement discovery was the essential occupation of the webcam in the shrewd mirror framework. The webcam ran whether the keen mirror is "dynamic" or "idle". Like clockwork, the webcam gathered a picture and contrast that picture with a reference picture taken the 30 seconds beforehand. Utilizing some fundamental picture sifting, a movement was resolved as obvious or bogus. At that point, the framework was either set as "dynamic" if there is movement or continue to check and be "dormant". At the point when the mirror is dynamic, the mirror checks for a movement like clockwork. Two minutes of no movement discovered will bring about the framework being set to "latent". At the point when dormant, the mirror checks for movement at regular intervals all together to perceive a client inside 10 seconds [27].

Proposed programmed techniques for client acknowledgment incorporate face recognition [10]. One of the method that can be used is using a deep metric learning concept. With this technique, face recognition is more accurate, around 99,38% accurate, almost perfect [25]. Face recognition will detect the face of the user and can be used to log in and verify the user's identity [4]. At first, the mirror shows up as a typical common mirror, and the camera will be dynamic, once the perceived the enlisted client then the face recognition of the user is requested, then the client is explored to the home screen [19]. It will make the machine can distinguish the users, so the user's data that displayed by the machine will be different for each user, and only the right user can access the data. User that not listed in the database cannot access the data and the machine will display nothing. The procedure of face recognition starts with the catch of the picture by methods for a camera, and this picture should be pre-handled to improve the difference [25, 18]. With these features, Smart Mirror also can secure users' data, so the data cannot be accessed by other people [26, 6]. With more development, Smart Mirror can be used for recognizing people's facial expressions and display them based on color emotion psychology [18, 26] or displaying people fatigue level based on their face [12]. Therefore for faces, the neural network compares the vectors and differentiates between the vectors of different datasets (where datasets are the faces of different persons) [5, 2]. Figure 4 display the process of face recognition, from camera, detection the user's face until recognize user's face.

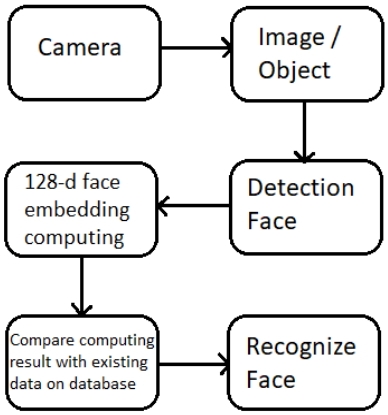

Fig. 4. Face Recognition Process.

Besides, various strategies for accomplishing cooperation proposed in the writing incorporate voice commands [16, 25, 11, 20]. Voice Control works by receiving input from user in the form of sound captured through the connected microphone. The voice will be processed by the smart mirror. In this process, the voice will be translated into text so the smart mirror could understand the input from user. Smart mirror will match the data from users with the data that is owned / stored

on the database. If the data received from users match the owned, smart mirror will act accordance to the data stored on the database/doing the task asked. If the data does not match the data owned, smart mirror will ask user to provide input again/say the command again. This is the way the voice acknowledgment framework works.

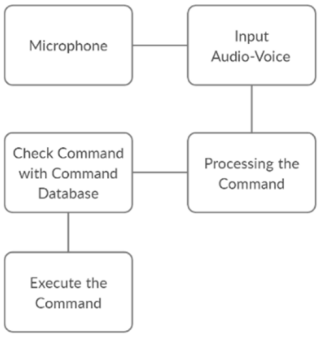

Fig. 5. Voice Control Process.

C. Features

The proposed framework permits clients to use a generally discovered family unit object as an intelligent interface for showing an assortment of data administrations and normal updates [10]. It was created with CSS, HTML, Python, and JavaScript parts, the plan and appropriation of the gadgets were redesigned to exploit each space of the mirror considering the new administrations that the Smart Mirror will show without dismissing the fundamental capacity of a typical mirror [25, 1].

Users can choose any highlights to be shown on screen. This keen mirror will be given a fascinating element that shows date, time, weather, traffic data, reminder, schedule, news source, information, and day by day update. User also can customize their display and widgets, so user can adjust the display to user preferences and make the interface as comfortable as possible [12, 21, 7, 11, 20].

People tend to forget about the schedule that they have to work on. Therefore, this machine will help users to remind user about their daily schedules, so user will not fall behind their daily schedule. User also can set a new reminder/alarm that is not related to their schedule. By providing a reminder feature, it is hoped that users can be helped to remember the activities that user have to do [8].

In the academic field, smart mirror can help students with accessing the application on the off chance that they need to think about situation subtleties, course plans, course enlistment, and route and need to post any inquiries. User can see a list of courses that must be done by user and make notes about planning these courses or regarding other problems. This feature can be done by collaborating and cooperation with user's school. With this collaboration, smart mirror will be connected to school's database. Smart mirror can display any school-related information and the detail about that information. With further development on AI, smart mirror can give advice and maybe solution on the problems that user faced. For example, smart mirror can provide advice on how the courses plans should be planned or how to create a good course plan. This will make student happier and enjoy his or her school life because user can choose and plan their course plan himself or herself. The application of this feature can be done by making the smart mirror as a facility for students and teachers. Smart mirror can be placed in the school environment, so students or teachers can use it freely. The system used by the smart mirror needs to be made so that it can record the history of the use of the smart mirror in the form of digital footprint. It can help schools in the process of maintaining and developing the smart mirror [10, 23, 29].

User also can manually add activities to their schedule and the detail about it, such as date, time, and description about the activities, smart mirror will also remind users about those activities. Another feature is creating a to-do list. By creating a to-do list and displaying it on the smart mirror, the users will be reminded about the task that must be done and the deadline. Activities in this to-do list can be added to the user's schedule. By adding it to the schedule, user can make plans about these activities and adjust it to the user's schedule. All of these features can be updated from the administrator devices. This will make a better school life. The student will remember every single homework and task.

Another features are face recognition and voice control. Face recognition can be used as log in authenticator or to verify the user identity. With this feature, user's data will be secured and the data only accessible by the user. Smart Mirror can work if user listed in the database of the machine. If user is not listed, then smart mirror will not run and do nothing. This feature shows the security of this smart mirror is guaranteed. Voice control can be used for smart mirror to do the task requested by the user, such as displaying specific information owned or set a reminder. This feature will increase smart mirror efficiency because user has to say the keywords and smart mirror will respond by doing the task based on those keywords. With these features, users will be more facilitated and helped when they want to do their tasks. If the command is not listed in the database, then the smart mirror cannot do anything. But, if the command is listed, then smart mirror will do exactly what user want to do [6, 25].

There is an additional feature that can be added to this smart mirror, feature to control non-smart devices, such as light and speaker. By connecting those devices to smart mirror using relay switches, user can control those devices from smart mirror. Utilizing voice control feature, user can turn on and off using their voices. For example, if the user says "turn on lights", the lights that connected to the smart mirror will turned off. This feature can be used to make user's life easier because user can turn on and turn off the lights easily.

IV. ADVANTAGE AND DISADVANTAGE

Smart mirror was tested with the expected user to distinguish the adequacy of the keen mirror for the day by day use. In that capacity, the smart mirror would be a significant innovation to be included their day by day life. An evaluation is carried out to find out the advantages and disadvantages of the system. Evaluation is carried

out to detecting bugs and errors in the smart mirror systems and identify user experience and system usability in using the smart appliance features. Data from the evaluation will be analyzed to find out the effectiveness and efficiency of the application will be measured and enable to identify future enhancement to be done in the smart mirror. The implementation of smart mirror will bring advantages and disadvantages.

A. Advantage

The smart mirror is intended to make human life simpler in this pattern and the advanced period. These days, individuals more pulled in to things that identify with web things. In the meantime, this mirror will have the option to give something that inconceivable stuff to all utilization and help to spare time [26]. Smart Mirror is the developing idea in this quick transforming IT world. This is the greatest advantage of the smart mirror, which prompts a protected driving condition and less use of the smartphone. In the future, there might be considerably more progression in this idea [2].

The use of this smart mirror will be very beneficial for students, especially in academic field. This device will be assisting students at every level, because mirror is a tool that is always used by people, regardless of their age. By displaying information about student's learning in the mirror, it will be easier for them to access their schedule and anything related to their study. It can also act as reminders, so the student will not fall behind or forget their schedule. It will help student to arrange their schedule neat and orderly, so any homework and task will have done more easily. This is very suitable for student.

The security of this smart mirror will be sufficiently maintained because the login system uses face recognition. With this login system, user's data will be secured because only user will be able to access it. This feature will ensure the security of user's personal data. If user is not listed in the smart mirror's database, then smart mirror will not run. User must be listed in the database to access this smart mirror. This is happening to make only right user to access the data and avoid hacker to hack user's data.

The use of this smart mirror will be relatively easy, because it will have voice control feature. With this feature, user can command the smart mirror to do its job using their voices. Some keywords / commands will be registered and programmed to smart mirror to do some specific job. For example, if the users say "show calendar", smart mirror will show the calendar with user schedule on it or "show today schedule" to make smart mirror display today schedule. This feature can be used to support user on their daily learning process. This feature also can help disabled people to use this smart mirror. Disabled people can use his or her voice to run the smart mirror.

According to paper [24], the error rate of voice recognition usage is approximately 0.5%, and the error rate of face recognition usage is approximately 4%. With a combination of the two, accuracy will be more accurate so mistakes can be minimized.

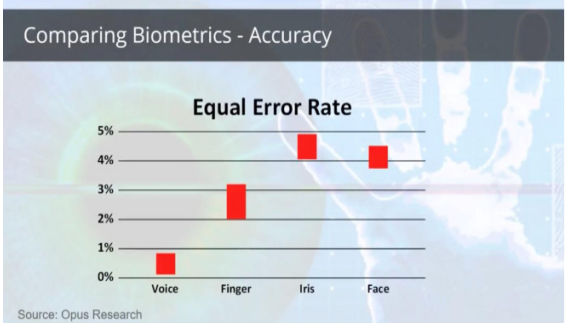

Fig. 6. Error Rate [29].

B. Disadvantage

One of the main challenges in the conception of the smart mirror was to provide built-in user customization capabilities [10]**.** Then, raspberry is a microcontroller with confined execution and limit. The synchronization of every one of these highlights into Smart Mirror is one of the challenges. Force issues, delays in content conveyance are a portion of the watched issues. Sometimes SD card might be defiled. Different burdens are cost and the strength of the equipment gadgets. To decrease the expense of the framework, one can utilize the freeware and open-source programming, however, they need ease of use. Subsequently, it might make it hard for programming and upkeep. The interfacing of the equipment and programming is a real test [29].

The interfacing of the equipment and programming is the real test. Legitimate information on equipment gadgets and sensors is compulsory for giving better and refined arrangements. Else it might prompt harm of the sensors and other associated gadgets.

Another challenge that will be faced in the development of this smart mirror is the AI feature that will be used on the smart mirror. By the time this paper was written, AI technology was still under development. It will make AI development for smart mirror stagnating. Developers need to find an appropriate AI development method that will make AI work according to user needs, assisting users in carrying out their task and the use must be easy to understand among users, because if it isn't, it will only make it harder for users to use the smart mirror. This thing needs to be considered because not everyone can immediately understand the use of AI which is by the time this paper was written, still uncommon, so it must be adjusted to the capabilities of the general public right now [9, 5].

V. CONCLUSION

This paper discusses the literature review on the creation and implementation of smart mirrors that can work with the utilization of Raspberry Pi. Smart Mirror has helped users from various fields of life who depend on the developer and what goals they want to achieve. Various types of features can be incorporated into a smart mirror. The value of this Smart Mirror is to assist in a series of daily routines to improve the learning process. Smart mirror also can help people to remember and do their daily life. This smart mirror will be given an intriguing element that shows the date, time, weather, traffic data, notice, reminder, schedule,

news source, and everyday update. With various features that can be added to a smart mirror, the smart mirror brings enormous benefits in helping human life. In general, smart mirror functions to be a personal assistant and notice board for users. But smart mirror also has some disadvantages such as technical and non-technical problems. The common technical issues related to the Raspberry Pi device while the non-technical issues include the expense and the sturdiness of the equipment gadgets.

VI. FUTURE SCOPE

The next step of this paper is to do a research for implementing the idea of smart mirror to enhance learning. In the future, research is carried out with the aim of finding the best method that can be used to develop this smart mirror. It is hoped that this smart mirror can help and facilitate human life.

ACKNOWLEDGEMENTS

We would like to thank the Bina Nusantara University for the opportunity to conduct this study. We also would like to thank Bina Nusantara University's lecturer for helping us in completing this journal. Last, we would like to thank the references source that help us in completing this journal.

Conflict of Interest: No potential competing interest was reported by the authors.

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How to cite this article: Thejowahyono, N. F., Phang, J., Darmawan, K. N. and Widianto, M. H. (2020). Smart Mirror to Enhance Learning: A Literature Review. *International Journal on Emerging Technologies, 11*(5): 226–233.