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Design and Implementation of Smart Mirror for Health Monitoring

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Abstract: A variety of environmental factors can obstruct human health and well-being. These challenges include chemical pollution, air pollution, climate change, disease-causing bacteria, a lack of access to healthcare, poor infrastructure, and poor water quality. What we need now is a mechanism to continuously monitor an individual's health in an intuitive approach that can be used regularly without too much effort. That's why we' re proposing to create a smart mirror hat can track a user's health. The smart mirror will monitor and display our heart rate, oxygen level, and body temperature.

Keywords - **Chemical pollution, Air pollution, Climate change, Smart mirror.**

I. INTRODUCTION

For health monitoring, a variety of approaches are available, as well as a variety of sensors. Early health monitoring approaches were clinical, in which people could learn to manage certain physiological functions by changing the belief sand perceptions that caused them with the help of skilled therapists, but they had to travel to specific sites where the technology was available. Individuals can now utilize biomedical sensors and the Internet of Things to keep track of physiological functioning from a far (IoT). Sensors are used in a variety of gadgets, including phones, watches, and other electronic devices. For individuals who are capable of using such devices, this technology is incredibly valuable. Elderly individuals, on the other hand, who are less able to use such equipment, health monitoring systems more than persons of other ages. This chapter explain show to use mirrors to create an effective health monitoring system that can be used by anyone of any age. The physiological data is collected by the bio medical sensors in the mirror and communicated to medical personnel so they can learn more about the patient's health. Doctors can keep an eye on their patient's health from afar using this method.

In this study, we focused on a smart mirror, which is one of these gadgets. A smart mirror is an electronic device that functions as a mirror but can also communicate with users and display information such as date, time, and weather on the screen, all while being hidden behind a reflecting surface. Smart mirrors come in a variety of shapes, sizes, and applications that can be used in academic, general, and medical settings using various implementation methods and programming languages. Previously, the smart mirror served only as an interface for displaying generic information. By integrating a sensor placed inside the smart mirror, the mirror can now predict the presence of the user in front of it, making it more interactive. A variety of situations. In the fashion industry, for example, the mirror may act as a consultant, guiding consumers through ha simulation to assist them to choose their attire. Furthermore, one of the most important fields use smart mirror to deliver the reputed and medical advice to patients is medicine. Smart mirrors are also employed as a learning aid for pupils.

There are a variety of health monitoring strategies available and many types of sensors that can be employed. Early health monitoring techniques were clinical, in which a person could learn to control specific physiological functions by changing the thoughts and perceptions that produced them with the help of trained therapists, but people had to travel to specific locations where the technology was available.

Individuals can now employ biomedical sensors to remotely monitor physiological functioning via the Internet of Things (IoT). Sensors are used in a variety of gadgets, including cell phones, watches, and other wearables. For individuals who can use such devices, this technology is quite beneficial.

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Elderly persons, who are less able to operate such equipment, require health monitoring systems at a higher rate than other age groups. This chapter provides a basic health monitoring system based on mirrors, which may be used by anyone of any age. The physiological data is collected by biomedical sensors in the mirror and communicated to medical personnel to provide them with information about the patient's health stat us. Doctors can use this method to remotely monitor their patient's health.

II. INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is a phrase for physical items that can connect to and share data with other devices and systems over the Internet or other communication networks. It includes sensors, computing power, software, and other technologies. The term "internet of things" is deceptive because dev ices do not need to be connected to the public internet; instead, they must be connected to a network and addressed separately. Because of the convergence of several technologies, including ubiquitous computing, commodity sensors, increasingly powerful embedded systems, and machine learning, the field has progressed. The Internet of Things can function both independently and collectively thanks to traditional disciplines like embedded systems, wireless sensor networks, control systems, and automation. Lighting fixtures, thermostats, home security systems, cameras, and other home appliances that can be controlled by devices linked to that ecosystem, such as smart phones and smart speakers, are all items that contribute to the consumer market's embrace of the “smart home" idea .In healthcare, the Internet of Things is also used.

What is a Smart Mirror?

An ordinary mirror can be transformed in to an intelligent artifact, i.e., “smart mirror”, by placing a semi-transparent sheet of glass over a digital screen and connecting this hardware to a computer within coming data and a camera (Fig.1).On a basic implementation, the screen can display real-time information about the weather or traffic patterns, alerts from emails, and calendars ,as well as data collected via wear Ables. This device represents what we call smart mirror version1.0 yet this simple product offers a substantial upgrade to this common instrument that has otherwise undergone minor innovations in thousands of years. Current consumer versions of this product focus on select markets that augment specific capabilities such as driver assistance10or virtual fitting rooms to try onitemsofclothing.11Textmayappearonaportionofthe rear view mirror to aid navigation, and lights may flash on the side view mirrors to alert the driver about objects within their blindspot.4Thememorymirrorallows people to explore award robe digitally by “wearing” clothes with different colors and patterns projected on to a persons body reflected in the emirror.6 These second-generation of smart mirrors fits within a growing set of technologies that integrate monitoring systems with personalize din formation and computer vision to help individuals achieve their health goals and have a more sign affiant role in health care.

These devices embed multimodal sensors multiple cameras, motion detection, lasers, micro phones, speakers—as well as software based on artificial intelligence (AI) into the original design and include the capacity to capture and communicate with multiples sources of data, linking them to the broader ecosystem of smart products and the cloud. Such sophisticated yet readily available hardware and software provide the tools to capture physiological measurements non-invasively and to create interactive capabilities based on tracking and recognizing gestures. The smart mirror 2.0representsa general-purpose platform that multiple stake holders—engineers, scientists, physicians, hobbyists, the general public—can use to collect large quantities of biomedically relevant data, and to develop a wide range of applications that address many healthcare challenges.

III. COMPONENTS

Raspberry Pi: Raspberry Pi is the key hardware component used in the smart mirror to display user-specific information on the monitor. It is a small single-board computer which

runs code on the operating system installed in it. This component has a preinstalled Operating system called Raspbian OS (Operating system), which is Debian based Operating system. The code can be written in any of the supporting language. This paper is based on JAVA Script. This helps the monitor to display weather forecast, date and time, email notifications, calendar, news-feed and music with the written code dumped to the device. This also includes the usage of web-based services to display weather, news and other information by extracting the information from the internet as tokens to present on the monitor in order to provide it to the users. To accomplish this, the Raspberry Pi module has a Wi-Fi module to connect to the internet. The voice recognition is achieved by receiving the input from the microphone connected via USB card which allows user to give the voice input to the mirror to set up reminder sand for conversations.

Temperature Sensor*:* We'll be using a GY-906MLX90614 Non-Contact Precision Thermometer for this project. It's a high-precision infrared non-contact thermometer module with an I2C interface that runs on either 5V or 3.3V. Key distinction between this thermometer and most others is that it takes temperature readings without contacting the object whose temperature is being checked. This is useful for monitoring the temperature of moving items, such as a spinning motor shaft or objects on a moving conveyor. The sensor can read a wide range of temperatures since it is not always exposed to the same temperature that it is monitoring. A built-in optical filter on the sensor blocks out visible and near-infrared light to reduce their impact on the measurement. It can use theI2 Cbus to communicate temperature commodify settings. It can continuously convey the temperature using a PWM signal, with the duty cycle of the signal representing the temperature. It can be used as a thermal switch to toggle the output at a pre-programmed trip point, such as in a thermostat.

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Pulse Oximeter Heart Sensor*:* MAX30100 is being employed during this project it is a sensing element that has a pulse measuring system and a vital sign monitor. It's an associate optical sensing element that gets its measurements by emitting 2 wavelengths of sunshine – red and infrared – from 2 LEDs, then police investigate the absorption of pulsing blood with a photo-detector. This LED color combination is good for reading information with the tip of one's finger. The digital output information is held on in a very 16-deep inventory accounting inside the device, and it's customizable through code registers. It connects to several microcontrollers through an associate I2C digital interface. Close lightweight cancellation (ALC), a 16-bit letter of the alphabet delta ADC, and a proprietary distinct temporal filter compose the heartbeat oximetry scheme within the MAX30100. It operates at extraordinarily low power, creating it excellent for powered systems. The MAX30100 needs an influence offer starting from one.8 to 3.3 volts. wearable gadgets, fitness help devices, medical observation devices, and alternative devices will all have the benefit of it. The MAX30100 runs on one.8V and 3.3V power sources, and it's going to be turned down by code with little or no standby current, permitting the facility offer to be connected the least few times.

Smart Mirror*:* A Smart Mirror is a two-way mirror with a built-in display on the backside of the glass. On the mirror's surface, the display can show the current time, weather forecast, news feed, scheduled appointments, and more. The capacity to display any information you choose on a Smart Mirror is what makes it "smart." Local weather forecasts, news bulletins, your forthcoming calendar agenda, social network feeds, and other information can all be displayed on a smart mirror. You may easily design a smart mirror to display whatever information you desire.

IV.A SMART MIRROR IMPLEMENTATION

We set out to build a smart mirror that examined some of the above technical capabilities with potential applications in a clinical or public setting (Fig. 2). We used readily available, off-the-shelf hardware components, and software tools to build our prototype in a few weeks. Our smart mirror is made from an LCD display covered with a semi-transparent glass. The screen connects to a logic unit based on Raspberry Pi that manages all the functions of the mirror via a GNU/Linux operating system. We followed a plug-and-play paradigm, which prized modularity and usability of third-party opensource software. The software infrastructure used a multi-tier architecture that allowed us to examine multiple services that could be relevant for different medical use cases. This scalable architecture enabled us to quickly prototype different features on our smart mirror, such as weather forecasts, environmental d at a, face recognition, location, mood detection, and breathing rate estimate. One limitation we encountered in building a smart mirror prototype is we found fewer than anticipated off-the-shelf services for healthcare that we could evaluate. Many features, in fact, still require additional research or technical development. However, we embedded different opensource services linked to healthcare, e.g., mood detection as a measure of mental health and facial recognition for personalization. Collectively, we confirmed the feasibility of creating an architecture for smart mirrors that could be tuned by a user based on his/her needs.

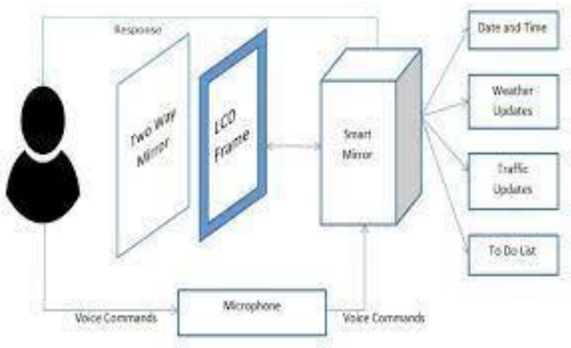

Figure.1. Smart Mirror Architecture

V. BRIDGING THE GAP: DEVELOPING SMART MIRRORS FOR HEALTHCARE

One takeaway from this sampling of use cases is the small gap between prototype and practice. The consumer-grade hardware and multimodal data analysis tools currently available can achieve results that are useful for both general health enthusiasts and patients.17,18 Plus, the trend of publishing specifications for how to build these devices increases the likelihood of finding smart mirrors in the wild that function as personal health assistants. Everyday environments such as houses, gyms, and offices now include prototype devices that provide context-specific information about personal health with nudges toward healthier lifestyles.19,20 Recent advances in machine intelligence are creating the opportunities to move from the proof-of-concept stage to reality more quickly. The science that helps machines to understand the visual world, known as computer vision, is rapidly improving from advances in a branch of machine learning that uses a hierarchical computational design inspired by a biologic neuron's structure, that is deep learning.21 Computer vision driven by deep learning algorithms can help inexpensive cameras achieve image acquisition performances comparable with high-end devices,22– 25 enabling new opportunities to embed medical-quality image acquisition in at-home devices, such as mirrors. This shift reflects a significant change because these diagnostic capabilities required expensive machines typically available at hospitals or large medical centers. Applications of deep learning and computer vision in medicine abound.26–30.

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Two fields where home monitoring with a smart mirror could change the traditional patient-physician interaction include ophthalmology and dermatology.
Retinal fundus photographs analyzed by deep learning networks measured potential cardiovascular risk factors, such as gender, age, and systolic blood pressure,31 and identified diabetic retinopathy and diabetic macular edema.32 One implementation of convolutional neural networks resulted in dermatologist-level classifications of skin cancer from clinical images.33 An AI-based dermatologist called SkinVision34 showed accurate classifications of skin abnormalities that could indicate malignant growths. Although these examples used a hand-held imaging device, embedding these algorithms into a smart mirror platform would address some of their current limitations such as passive monitoring, removal of hand coordination, and bona fide comparison images captured under more reliable conditions. Two other digital health domains that can benefit from smart mirrors are anthropometry and functional movement. Defining the relationship between the locations of joints and their position in images is called human pose interpretation. Once again, computer vision and deep learning outperformed the state-of-the art in detecting, tracking, and deciphering humans and their body pose.35–37 These technologies can leverage the smart mirror for a range of healthcare tasks, such as orthopedic diagnostics, physical therapy, personal training, adherence, and health and fitness. For example, the Smart eHealth Mirror design framework captures a person's posture, conducts an anatomical analysis to determine deviations from optimal alignment, and then provides suggestions for making adjustments to improve individual posture over time.

BMI TEST

According to Kim et al. [47], BMI is considered as an efficient technique of gauging the amount of fat present in the body since too much body fat can be life threatening. The body mass index (BMI) of a person is obtained as the ratio of body weight (kh) to the height (m). The theoretical ranges as proposed by health digest, [52] as follows: underweight: 30. A number of users with varying height participated in this experiment. The ultrasonic sensor was used to record height of the users whereas a weighing scale was used to compute their respective weights. The BMI was computed and the values obtained were recorded. The data obtained from the BMI test illustrates that the implemented system is able to monitor the body mass index of the users irrespective of their gender. However, a minor discrepancy was observed between the measured and theoretical values. The minor error observed was mainly from the minor deviation between the measured height and the theoretical height. This is because the implemented height measurement system relies on an ultrasonic sensor which operates based on the ultrasonic waves bouncing off the uneven head surface. Therefore, the user needs to be in a still position for at least 5 seconds for the ultrasonic sensor to take accurate readings.

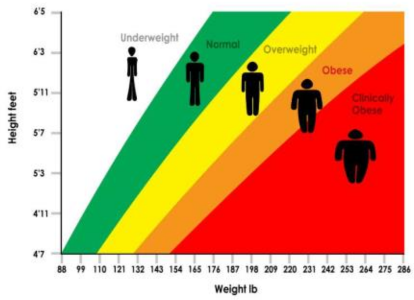

Figure.2.BMI Chart

TEMPERATURE TEST

Body temperature has been used a measure of body health over the decades and still remains a vital source of information related to health and body fitness [51]. Abnormal body temperature i.e. above or below 37° is considered as a sign of illness or abnormal body activity. A non-contact infra-red temperature sensor was used to measure body temperature of the user standing in front of the mirror from the forehead. The theoretical temperature ranges for normal human body temperature are as follows: normal (36.1-37.8), fever (>37.8), and hypothermia (<36). The temperature of different users standing in front of the mirror was obtained based on different genders and distances away from the mirror as shown in Figure 16. The measured temperature of the users was then compared with theoretical temperature values which were obtained by means of a digital thermometer shown in Figure 16.
Temperature data collected from the IR temperature sensor illustrate that the implemented temperature monitoring system is able to read human body temperature from the forehead. The system was able to respond in kind to temperatures below and above the set threshold whereby only a minor discrepancy was observed between the measured and the theoretical values.

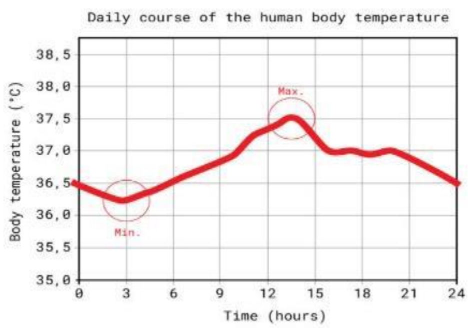

Figure.3. Body Temp. Data

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PULSE OXIMETER(SPO2) TEST

Pulse oximetry's significance in healthcare is introduced alongside the potential of smart mirrors to offer accessible and comprehensive health-related features. The study outlines its objectives, emphasizing the contribution and benefits of combining pulse oximetry with smart mirror technology. A thorough literature review covers the principles of pulse oximetry, existing technologies, and the applications of smart mirrors in healthcare. The methodology section details the selection criteria for both the smart mirror and pulse oximeter sensor, highlighting the integration process and software development for real-time data processing. Testing and calibration procedures ensure accuracy and user experience, with results presented and discussed, comparing them with standard devices. Privacy and security considerations are addressed, focusing on data protection measures and compliance with regulations. The conclusion summarizes key findings, implications for future research, and the potential for enhancing health monitoring through smart mirror technology. The paper aims to contribute to the evolving field of health-focused smart devices, emphasizing accuracy, user experience, and privacy as integral components of integrated systems.

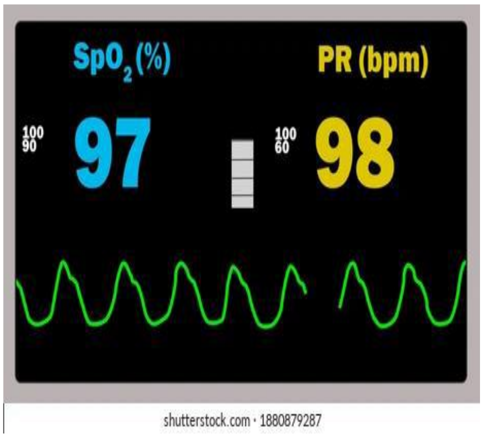

Figure.4. SPO2 & BPM

VI. OPPORTUNITIES AND BENEFITS

We foresee a near future where smart mirrors represent an integral part of daily life analogous to smartphones. Mirrors offer greater convenience and capabilities for monitoring personal health outside of the traditional medical settings of clinics and hospitals. The technology provides easy monitoring and data collection. The data collected from a mirror can link with wearable devices or other smart products to offer daily personal check-ups.39 Furthermore, this data can connect to the electronic health records and then be shared with the appropriate healthcare professional, e.g., physician, trainer, physical therapist.40,41 Passive monitoring capabilities on the smart mirror can determine baseline conditions and detect deviations that indicate potential changes in health.

The device collects relevant measurements while a person uses the mirror as part of their typical routine rather than having to carry (and to recharge) additional hardware. We believe this principle is one of the critical points for increasing the adoption of smart mirrors to improve personal healthcare: the technology should fit with and support a person’s activities rather than having the individual change their habits to use the new technology. In such scenario, all the data are silently collected without any obtrusive interaction and provided to the users (or shared with the personal physicians) only when requested (or in presence of anomalies), and potentially as summaries or longitudinal trends. This helps minimize the risk that individuals are inundated with too much information to process, and might decide to tune out some of the signals. A common household location for a typical mirror is the bathroom. Swapping in a smart mirror permits the collection of health metrics such as body temperature and heart rate, as well as changes in skin features, e.g., color, texture, moles, rashes, while a person goes about their routine. All of these parameters represent meaningful markers of health and this idea represents a second core principle for smart mirror technologies: at-home monitoring promises new possibilities for more accurate and useful diagnostic metrics in a convenient setting that captures reality more closely. Smart mobile devices, such as wearables, smartphones, tablets, and laptops, can be used for health monitoring as well, often with no additional costs.42 However, individuals are required to actively do the monitoring by setting up the laptop for motion detection, keeping a device always charged for heart rate measurement, or taking pictures of eyeballs or skin areas for ophthalmology and dermatology analysis. Most importantly, users often need to identify that something is wrong with their own body and act based on it. Cameras embedded in the bathroom mirror or elsewhere in the home could help to more passively predict health issues before they manifest clinically. All portable device ecosystem can serve the users for not-at-home monitoring, with these measures integrating the smart mirror data towards more consistent and reliable observations. Smart mirrors for personal training can replace the regular mirrors in most gyms.43 In this context, members could receive guidance, motivation, and encouragement for particular exercises. The same scenario applies to physical therapy, whereby the patient uses biofeedback in performing the recommended exercises. A smart mirror at-home offers the option of recording movements to share this information with the person’s physical therapist and tracking progress.

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VII. LITERATURE REVIEW

No.	Title of the Paper	Year of Publication	Author	Description
1.	An IoT based patient monitoring system using raspberry Pi	June 2016	R . Kumar	Monitoring patient's body temperature, respiration rate, heart beat and body movement using Raspberry Pi board brings out the solution for effective patient monitoring at reduced cost
2.	Health monitoring based on IoT using Raspberry PI	Feb 2017	kaur	A system for monitoring of pulse rate, body temperature (vital body parameters) of the person with dedicated sensors along with Raspberry pi and IoT, which is wearable and also supports remote health monitoring.
3.	Smart Mirror Using Raspberry Pi- International Journal of Engineering and Techniques	2018	Mr. John kete	Smart mirror is to increase a user’s productivity by saving them time.
4.	Smart Mirror Using Raspberry PI - International Journal for Research in Emerging Science and Technology	2018	Mr. William Matthew	Simplify life by reducing the constant need to check phones, tablets, or PCs for date, time, news, and weather.
5.	Design of Smart Mirror Based on Raspberry Pi”, International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)	2018	Ms. Scarllet Jane	The designed intelligent mirror has the advantages of small size, simple operation, low cost, and is suitable for families, and has broad application prospects.
6.	IoT based Smart Mirror using Raspberry Pi	2018	Lakshmi N M Nagarur Meena	"Smart mirror with IoT for displaying info and home security with thief detection in an elegant interface."
7.	Smart Mirror: A Journey to the new world	2019	Pratibha Jha1, Prashant Jha, Mufeed Khan, Kajol Mittal	"Smart Mirrors combine mirrors with information services, offering weather, time, and more through user-friendly interfaces."
8.	IOT BASED SMART MIRROR WITH NEWS AND TEMPERATURE	2020	Apurva Joshi	Raspberry pi stays at the back scene and controls the data displayed on the mirror while the LED display that is placed behind the twoway mirror can serve various applications.
9.	An IoT based smart mirror	2021	Gias Uddin Parvez Uzzal Kumar Acharjee	The aim is to build a low-cost intelligent mirror system that can display a variety of details based on user recommendations.
10.	Design of Smart Medical Mirror using Raspberry Pi	Jan 2023	R Mariappan	The main idea of the paper is to get individuals to monitor their body mass index (BMI) and temperature. The BMI is a technique used to test people for potential weight issues and to track the weight status of people.

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VIII. APPLICATIONS OF SMART MIRROR

1. A smart mirror that serves as a personal assistant to address the problem of time management that many people experience. It shows time, weather, and news, among other things. Users can browse and change daily schedules for numerous users, as well as read and reply to emails. The mirror also has a graphical keyboard that users can use to interact with it.
2. A smart mirror for use in smart home communications. This smart mirror is significant because it is efficient, intelligent, safe, and reasonably priced. In addition, we created this smart mirror using the unidirectional photography idea. In general, the results demonstrated that the smart mirror improves safety by comparing the user's face to previously recognized faces and sending an alarm if non-conformity to the owner status occurs.
3. The system was created with either an Arduino Uno or a Raspberry Pi. A plasma panel was also used to display some system capabilities such as face and voice recognition, speech playback, remote control, Wi-Fi connectivity, and a clothing indicator. The control module, display module, clock module, wireless transceiver module, and Bluetooth module all made up the smart mirror. In general, the findings revealed that a low-cost smart mirror may be created utilizing simple materials and an Arduino Uno or Raspberry Pi.
4. A smart mirror that acts as a virtual fashion adviser, analyzing, estimating, and recommending appropriate attire and outfits. Users have been guided to figure out what to dress using AR and gesture recognition under fashion directions. In 2d visualization, there are also icons to choose the outfits.
5. FitMirror, a smart mirror, was invented as an interactive gadget to improve the user's mood and motivation while also having a good effect on the user's feelings. FitMirror also encourages users to get up and work out first thing in the morning. In addition, the mirror was linked to the Android Fit program, which displayed the users' exercise data, as well as their pressure and stress levels, over a week. Touch or voice are two ways in which the user can communicate with the device.
6. An automatic personal cosmetics system was created with the help of a smart mirror. The device uses a smart mirror to identify makeup aspects that are best suitable for a user's face by applying them to facial photos. Furthermore, the system was constructed using Machine Learning (ML) and AI approaches during the analysis of users' faces.

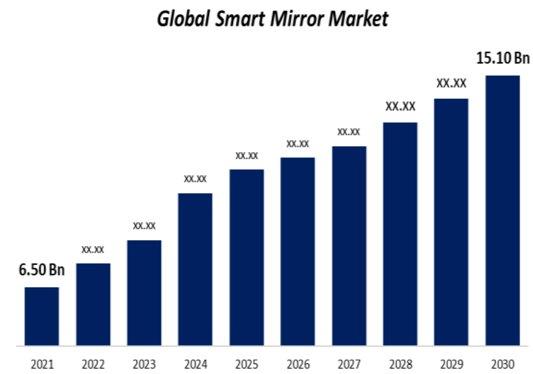

Figure .5. Global Smart Mirror Market

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