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INTEGRATION OF M HEALTH AND SENSORS IN HEALTHCARE

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Abstract
The growth of sensor technology has been abundant so this technology can be utilized to expand the mobile health to the next level. This article mainly focuses on the integration of m-health and sensors used in the healthcare industry. The study explains about the sensors, its types, and uses in detailed manner.

Keywords: Sensor analytics, m-Health, Artificial Intelligence, Smart Band and Technology

Introduction

The word sensor is derived from a Latin word that means to perceive or feel it senses the physical stimulus such as heat light , sound pressure, magnetism or a particular motion and it pauses on a resulting impulse for measuring or analysing to make some decisions based on it. These devices' sensors transform signals from one energy state to an electrical signal. The usage of sensors in healthcare is enormous and it can also have an impact on mHealth applications. The main problem faced by these applications starts at the time of developing these applications as they lack security guidelines, lack of knowledge on M health among the app developers, lack of security testing, and much more. As these applications are applied in many crucial situations the utmost care should be given during the time of development. Many countries are focusing on healthcare delivery technologies to boost their economy by implementing various legislative regulations such as the Digital Healthcare Act introduced by Germany in December 2019, the Digital Health and Care 2020 action plan by the European Union, the NHS Digital Healthcare Technology Standard by the UK in 2020, and so on.

India has also developed multi-fold healthcare and medical device regulations through the execution of the IMDR (Indian Medical Devices Rule) in 2018. There is some incomplete and inconsistent information that needs to be addressed, so the need for implementing gold standards in developing medical devices needs to be performed by the government. This chapter addressed some of the points which can be useful to understand the fundamentals of sensors, the type of sensors used in healthcare delivery and their importance in today’s scenario.

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Figure No.-1
Co-authorship Analysis based on Countries

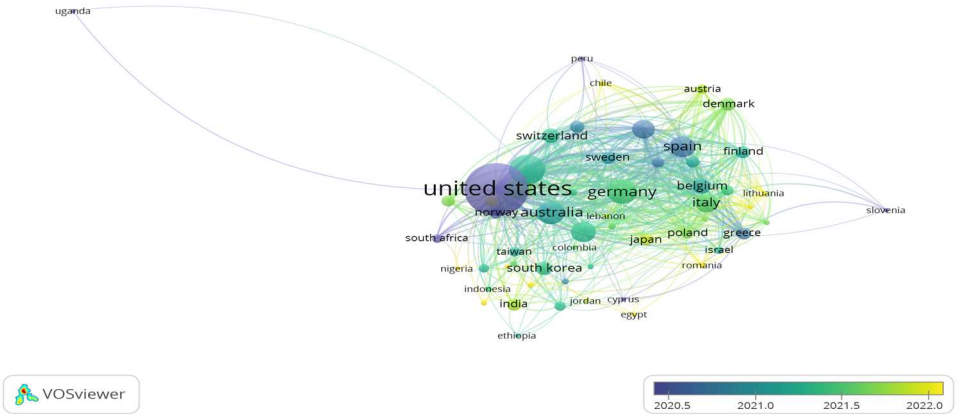
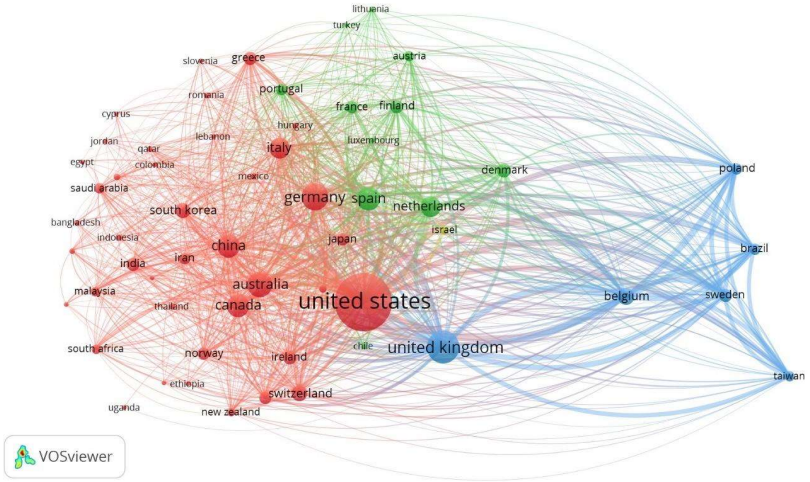


Figure No. 1.1
Bibliometric Coupling of Citation with Countries



Fundamentals of sensors

The simple form of sensors has three crucial segments which are

1. Sensing elements like transistors, capacitors, photodiode, etc
2. Conduction of signal and processing,
3. Sensor interface.

These sensors are classified based on the five major properties such as primary input, quantity transduction principle, materials, and technology implied, based on the property used and its application.

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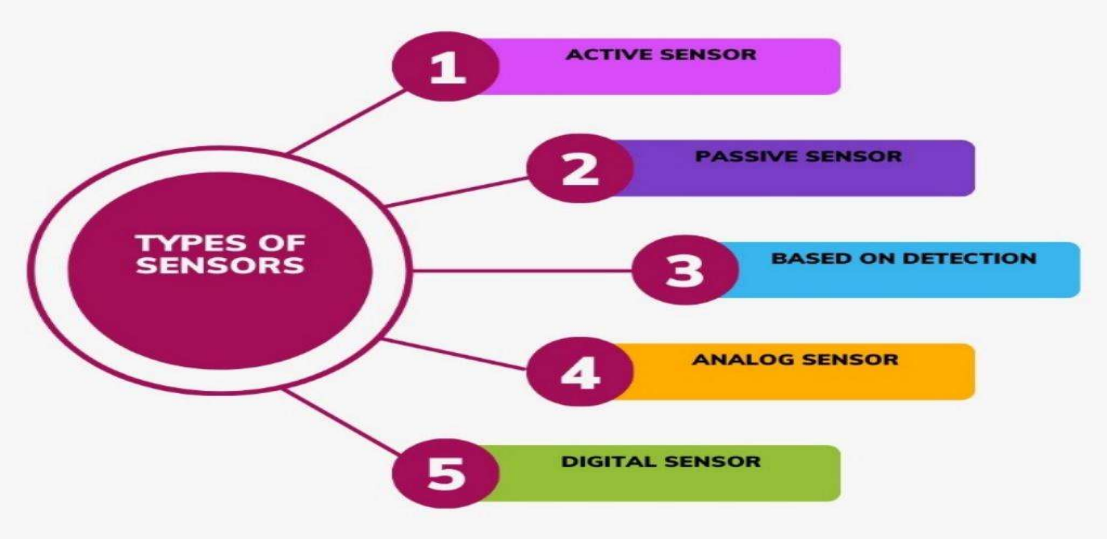
Sensor varieties

The sensors are classified into five major categories such as

1. Active sensor,
2. Passive sensor,
3. Based on Detection,
4. Analog sensor,
5. Digital sensor.

Figure No.-2
Types of Sensors



1. Active Sensors - This type of sensor requires superficial power for their work which is also called excitation signals, these signals are generated by excitation waveform. These signals are modified by the sensor to produce the output the sensor specifications are sometimes regulated by these excitation signals and these effects are converted into electric signals so they may also be used as parametric sensors.

2. Passive Sensors - These sensors do not need any outside force to operate but they directly result in an electric signal in response to an external stimulus i.e. Which means that input stimulus is directly converted into output stimulus. That is the reason for naming them as direct sensors.

Table No.-1
Comparison of Active Sensor and Passive Sensor

S.No.	Active Sensor	Passive Sensor
1.	It measures positioning and speed accurately	Unable to generate the information like the other one
2.	Very costly	Very cheap

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3.	Provide their energy for Illumination	Deduct energy, only when it is available
4.	Can we use it any time of the day	It can be used only when there is energy available

3. Based on Detection - These Sensors are used in biological chemical radioactive etc.
4. Analog sensor – These censors will produce analog output.
5. Digital sensor – These types of sensors take analog data as their input and produce them as discrete digital data.

Examples of Active and Passive Sensors

Camera

It uses both active and passive sensors. During sunlight there is enough light to reflect the object so it captures it, this time it uses a passive sensor, but during cloudy or rainy days it uses its energy that is flashed to capture the picture this time it uses an active sensor.

Radar

It is used by police to detect the speed of that vehicle.

Examples of Active and Passive Sensors in Healthcare Industry

Light sensor

This can be used at the time of PPG and optical imaging.

Temperature sensor

It is used to detect the changes in temperature in our body or a place.

Pulse oximeter

It is used to measure the oxygen level in our body by detecting changes in light absorption.

Ultrasound sensor

These sensors send sound waves to create an image of our body during the time of pregnancy and visualize the heart at the time of any cardiac disease, abdomen, and other parts.

Smart sensor

Their name itself suggests it is a smart way of measuring things. These devices gather inputs from the physical environment and process them with the help of built-in processes and predefined workings by which they give the output. These sensors are more accurate as they are not affected by spurious noise among the recorded items. The sensors used the most crucial and fundamental component called IoT. The reason for using IoT for transmitting data is that it gives unique identifiers for those data over the Internet. In crisp, smart sensors consist of one microprocessor sensor and some form of wireless communication technology.

Among other fields, medical and healthcare delivery has been enormously influenced by the miniaturization of sensors, IoT Healthcare applications and wearable devices. These lightweight quirky designs Provide various opportunities for healthcare professionals to remotely monitor home-rehabilitation early direction of some pathologies and more. IoT helps to connect all animate and inanimate to create exhaustive changes as it is more convenient and dynamic. The objects connected to different network media help them to act as smart ones. IoT compresses various technologies such as

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the cloud, mobile devices, virtualized environments, and sensors. radio frequency identification (RFID)and AI. The IoT connects physical and virtual things over the Internet. IoT was developed by Kevin Ashton in 1999. By integrating cloud and IoT one can provide remote healthcare by reducing latency, and energy consumption and improving data privacy. By introducing a virtual cloud carer, remote monitoring and rehabilitation can be enhanced. Cloud computing provides on-demand products from shared sources while IoT offers self-configuring capabilities combining both is called the Cloud of Things (CoT). The prominent features of IoT, CoT, and Cloud are as follows

Table no.-2

Comparison of IoT, Cloud, CoT

S.No.	IoT	Cloud	CoT
1.	The placement of Resources is widespread everywhere	Accessing resources from everywhere	It can be placed and accessed from everywhere
2.	Deals with real-world	Deals with the virtual world	Deals with both real and virtual world
3.	Restricted capability to store and compute	Virtually unlimited to store and compute	Virtually unlimited to store and compute

IoT uses RFID to identify and track things, sensors to find changes in the physical environment, smart Tech to improve network power, and nanotech to connect little things to other things in the network. Communication that can be done both manually and remotely is called intelligent communication. This intelligent communication system can be connected with multiple networks such as the Home area network (HAN), Personal area network (PAN), and Metropolitan area network (MAN), and these devices can be interconnected.

Table No.-4

Comparing PAN, HAN, and MAN Network system

S.No.	Basis	PAN	HAN	MAN
1.	Size of the network	Smallest of all	Small compared with the MAN	Wide range of network
2.	Range	10m range of connectivity	Connects within 200m. sq.	5-50km range of connectivity

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3.	Usage	Enables a single person's device to connect	Enables Communication between sharing of resources with smart devices over a network	Used to connect citizens to various Organisations

Type of Sensors in Smart Watch

The Smart Watches consist of various sensors according to the brand that builds them but some common sensors include

1. Accelerometer
2. Heart rate monitor
3. GPS
4. Gyroscope
5. Barometer

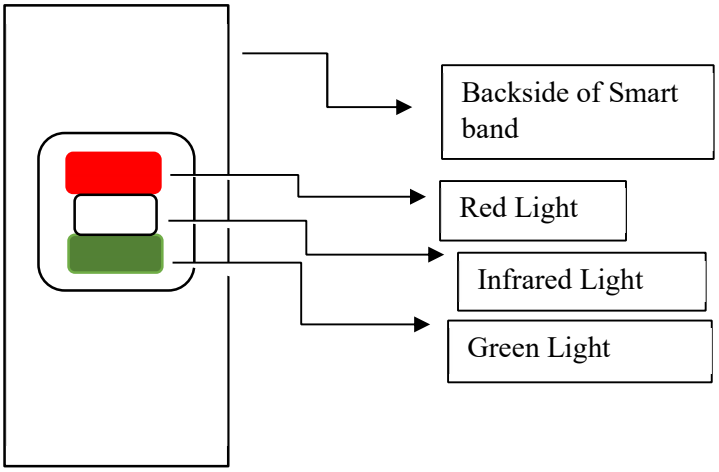
Accelerometer- To monitor calorie burn and more

It measures the acceleration or rate of change in velocity. The term velocity of an object means the displacement covered by that particular object per unit of time in a particular direction. It helps in measuring movements, activity type steps taken, distance traveled and calories burned. It also helps in monitoring wrist gestures and shake-to-wake.

Heart rate monitor

The heart rate of the user is measured with the help of optical heart rate sensors. Optical heart rate sensors measure pulse waves which occur due to the changes in the volume of blood vessels at the time of heart pumping blood. The article sensors are used to measure the heart rate because these sensors measure the high quantity of light that is present in the blood vessels and turn them into electrical signals which can be interpreted by some electronic instruments or health applications. These sensors block ambient light such as red light and infrared light in the environment so that they can produce accurate results. This technology supports low brightness, and low VF LEDs make it possible to work with low power consumption which helps the wearables to work long duration without frequent charging.

Figure No.3
Lights Arranged in Smart Band



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Red light and green light

Greenlight

The most common type of light used in smartband is green. This green light uses a process called photoplethysmography (PPG) To measure the heart rate. PPG is an optical technique used to find volumetric changes in blood due to blood flow distribution. Here optical refers to the light. In this process, PPG uses a light(green) Into our body's surface to record its intensity when the blood passes through the superficial layers and then utilizes processes to convert them into electrical signals that can be analyzed. This PPG technology is centuries old hence it is facing various challenges to meet current century needs.

" Humans are very good absorber of Green Light"

So, our body observes this green light and does not allow them to penetrate our skin. This technology can only work if the light passes through our body to measure the pulse wave. However due to its absorbing capacity. The green light fails to capture the movements inside our body. The next critical problem that has to be considered is the flow of fluids or blood cells near the wrist is minimal which makes these signals weak to perform the required action. Another critical problem is our skin tone. Our skin tone is made up of melanin which is a good observer of green light, which means that people who have high melanin content in their skin cause poor penetration of green light, this can also happen in tattooed skin. Thus, the green light is unable to measure the hydration level of our body as the light needs to go deeper into tissues to monitor it.

Red light

This red light uses a process called pulse oximetry which means using red and infrared space to measure the heart rate and various other aspects of people's wellbeing like SPo2 etc. Red lights have been used in hospitals for monitoring patients in operating rooms and ICUs for decades. The particular reason for using red light in the sensor is that red light cannot be observed by our body which helps them to go much deeper and measure the changes accurately. The red light can see multiple tissue beds at the same time so it can check the many changes that took place in our tissue at a single flash.

Another reason is the range of wavelengths in the near-infrared spectrum span from around 650 to 110 nm. This broad Window helps the sensor measure them accurately all at once. The next reason is that red light is transparent to melanin so it is not affected by melanin.

GPS (Global Positioning System)

Remember to turn on the "location" option on your mobile- This is the dialog we always think of while using GPS. This system uses satellites to determine the device's location. These types of satellites circle Earth twice a day which transmits a unique signal. This unique signal can be decoded by the GPS to find users' precise Location. The GPS receives this type of signal from a couple more satellites so that it can measure one's location meticulously. To measure one's latitude and longitude the GPS must get signals from at least three satellites. So, to measure one's latitude, longitude, and altitude i.e. 3D picture One must get a signal from four or more satellites. Generally, GPS is built up to 24 slot arrangements so that it can capture at least four signals. It can track up to eight or more based on the time of the day and where one is located on the Earth. Once it is located, it can measure the speed, trip distance, distance to reach one's targeted location, and more.

Gyroscope

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Gyroscope sensors are also called angular velocity sensors which can find changes in rotation angle per unit of time**.** This helps the sensors to measure screen rotation, step counting etc. Angular velocity in simple terms means how fast the body rotates concerning its center of rotation i.e. it measures the time taken for one rotation.

Barometer

This Sensor measures the atmospheric pressure. It is used to measure altitude, weather forecast, and track the elevation during rock climbing and other sorts of activities. The barometer has to be calibrated every time before using it. There comes the need for GPS as it uses the current location which helps the barometer for its consistent results.

The above are the main sensors that work to measure the movement of one's body. These sensors should work together while performing any physical activity to measure its intensity, type of activity, calories burned, duration taken, and much more.

Need for Integration of Sensors with mHealth Application

There is always a need for affordable and reliable mobile health applications that can focus on the collection, communication storage and analysis of healthcare data. Approaches like machine learning, remote cloud-based, IoT-based, and wearable technology can be used for cardiac health. These technologies help healthcare professionals and patients to get up-to-date health information. The technologies can help more elderly people who are in desperate need of remote consultation as of now the growth rate of elderly people is increasing as there are more angry populations in today's scenario.

According to India's aging report 2023, the increase of senior citizens i.e. aged 60 years and more will rise to 20.8 percent of the population in the year 2050. As of now 10.5 percent of the population in India are senior citizens. The Indian monitoring system for wearable devices is based on wi-fi fingerprinting or need of the day. This system uses Wi-fi wearables access points which are then used to build machine learning algorithms to locate the users of this device using the Wi-fi signal strength. This type of system does not need any additional infrastructure so it is a cost-effective and efficient way of indoor monitoring.

Machine learning technologies use past data to scan and find patterns based on that it can learn, grow, and develop itself so it can merely imitate human behavior. These technologies help to look over the pulse rate blood flow blood pressure haemoglobin content in blood and compare them with the already available data i.e. The normal range recommended by doctors which helps them to compare the particular person's data to find the person's health condition. In case there is a surge or sudden fall in heart rate it can immediately alert the caregivers or doctors who deal with that patient.

The ensemble classifiers and the Bayes network classifiers of the machine learning system provide greater accuracy and reliable results. This system can also support the battery life of wearable technology. Machine learning can't detect the false while walking by auto-coding the Gaussian process dynamic model by scrutinizing dynamic walking patterns to detect faults with built-in wearable sensors in smartphones and smartwatches. As these devices are equipped with multiple sensors they can detect health information by inspecting people's daily activities. The Gaussian process in machine learning refers to the normal distribution of data which can be used for probabilistic modelling, statistical interface and algorithm design; it forms a bell-shaped curve with more values clustering around the mean. These classifications can measure the user's location accurately ranging from 92% to 100% but

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without location information, it may fall up to 50 percent in some cases.

The main sensors such as tri-axial wearable motion sensors such as accelerometers, gyroscopes and magnetometers can capture the body movements these sensors not only capture the body motion but also the direction of the smart band placed. The Smart Band which is placed in the wrong direction will not provide the desirable results. Many healthcare providers do not take this as a serious issue, but the remedy provided based on these results may go wrong. To achieve this orientation invariance with wearable motion sensors in activity recognition the required sensor data has to be transformed so that they become invariant to the orientation by which the place of the body is fixed. The censor in wearables must be placed in a comfortable location so that the biometric system can monitor it. This Biometric system can acquire PPG, ECG, ACC, and GSR signals from the wrist. The PPG sensors such as transmission-based and reflection base can be used to gather data from our bodies. However, there is a limitation for transmission-based sensors that is they cannot be worn for a long duration. However, the reflective type sensor can be easily placed in any part of our body.

ECG (Electrocardiogram) is done to measure the electrical signals that can be produced by your heart. These signals are created by one heartbeat with two intervals and a U wave which is usually invisible. An ECG sensor must have at least two metal electrodes which should have direct contact with the skin to measure the signals the ECG sensor used in hospitals can have 3, 5, or 10 electrodes which are placed around the chest but it cannot be possible for daily life but wearing chest fitness straps, ECG T-shirt with just two electrodes can monitor the heart condition of the patient. These ECG t-shirts have very ultra-thin sensors with special electrodes that are woven in cotton or synthetic yarn. The readings are uploaded to a cloud-based database via wi-fi or to a monitoring device like a mobile health application. These t-shirts can't point out any irregularities in the heart condition which alert the doctors.

GSR- Galvanic Skin Response/ Skin conductance

GSR measures the electrical conductance of skin i.e. it should have direct contact with the skin. It has two electrodes one inch apart in one electrode it can send a current that is subtle and tolerable by humans and on the other end it can receive the current i.e. the signals to interpret them. This sensor is used to measure the stress level, pain, and stress caused by any physical activity in the wearer's body. These signals can also be affected by sweating which cannot be controlled. Usually, this GSR is used as a light detector as it can significantly increase when the person is under stressful conditions.

These sensors can also help in psychology to monitor the emotional state of the people. Emotion sensors can gather data from people and segregate them into positive and negative emotions. These emotions are not only connected to the mental well-being of the people but also the physical condition. Negative emotions for a longer duration may cause headaches, asthma, ulcers, and heart diseases. In India, Ischemic heart disease is the leading heart problem that causes most of the deaths at present. The reasons for the rise in heart disease include urbanization, unhealthy diets, rising stress levels, and sedentary lifestyles. These diseases are preventable by following necessary precautions. The ultimate fact of this condition is that it occurs 10 to 15 years earlier than in Western countries.

The national mental health survey conducted by WHO from 2015 to 16 found that one in twenty adults in India suffers from depression. In the same, a UNICEF survey conducted in the year 2021 Found that 14 percent of 15 to 24-year-old Indians are depressed frequently. So, the need for monitoring mood swings and mental state arises. These mood swings can be monitored by heart rate as it is difficult to

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control. Using heart rate, to measure mood swings will be accurate because they are objective compared to facial expressions. Many studies have proved that heart rate varies based on more changes. The physiological signal has a unique response to different emotions. EEG (electroencephalogram) can measure emotions 80 percent accurately.

Many models have been developed to measure the emotional well-being of the patients. EEG sensors need to be placed in one's head to capture the signals but it is not possible in routine life so researchers have developed a smart band to gather physiological signals that can be measured by the band on the wrist. Further, these signals can measure emotions while watching short-term videos but this can be done under close supervision of a doctor in a controlled environment. In recent times this is possible in indoor environments not controlled under supervision and by wearing a smart band. These data are gathered in health applications which can be scrutinized using machine learning and deep learning algorithms.

In-depth exploration of healthcare applications

Mobile phones have become widespread due to their significance in our day-to-day activities. The health delivery can be improved by using the health applications through mobile phones these programs are called mobile health applications/ mHealth apps. M held on mobile health refers to the wireless technologies being utilized to provide public health. It can provide proactive measures instead of reactive services to protect health. The mHealth devices or applications help users to record their health data.

According to WHO digital health has been classified into three main groups based on the user's perspective.

1. Clients
2. Healthcare providers and
3. Health system /resource managers

This type of classification helps healthcare professionals and technology-oriented audiences to get the required knowledge about the latest updates on healthcare. The primary need for categorizing digital healthcare systems is based on four major uses.

They are

1. To harmonize evidence and research
2. Conducting inventory analysis
3. Expanding guidance resources
4. To express the required digital functionalities based on the identified challenges in digital health.

WHO listed 8 main health system challenges that are faced by various countries worldwide.

1. Information Challenges such as delayed reporting of events, communication roadblocks, and lack of access to information on health data.
2. Availability Problems such as insufficient supply of commodities and services, and lack of health workers to serve unnoticed populations.
3. Problems related to quality include Insufficient patient experience, inadequate supportive supervision, poor quality health commodities
4. Acceptability problems related to programs that do not provide individual benefits
5. Obstacles related to the utilization of Geographical inaccessibility and loss of follow-up

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6. Challenges related to efficiency include lack of referrals, delayed provision of care
7. Cost problems include client-side expenses high cost of manual procedures and much more
8. Accountability challenges arise due to inadequate patient engagement lack of transparency in transactions etcetera

The need for proper healthcare delivery has to be implemented with the help of mobile health applications. Scale-based clinical data collection and standardization can support health information networks and exchanges which helps doctors to suggest treatment plans. Personalization of health plays a major role in implementing digital health all over the world, gamification and rewards can further help to ensure that digital healthcare.

Gamification in health and fitness enhances the user's participation in health and fitness apps. Gamification means including gaming elements in a non-game environment to attract users. This gamification is done to boost motivation while doing workouts as it forms an interactive experience such as reward points for doing exercise following routines for longer duration, accomplishing tasks and so on.

Here are some of the examples

Headspace

Headspace is a meditation app that helps to build habits through gamification. The unbroken streak of practicing meditation helps the users to gain badges which makes them more consistent to meditate.

Fitbit

Fitbit focuses more on sedentary lifestyle changes of the users and it introduces achievement badges to motivate them to move more.

Zombies, Run

This app gamifies your running routine by introducing you to an app post-apocalyptic world. The player has to collect supplies and escape from zombies which makes your daily fitness goal.

Sweat coin

It is a unique app that provides sweat coins for one's walking or running which can be redeemed as products or services or donated to charity.

These apps pay the users by combining GPS and motion sensors to track the activity the amps after downloading ask for location access and the smart band which is connected to them helps to locate them accurately.

Future challenges

In the current trend ultrasonic motion sensors are facing a steady increase and their need can be seen in smart home security systems and more. The future may require biomedical sensors that can sense technologies with a focus on functional materials, novel sensing mechanisms, design principles, fabrication and characterization techniques, multiplex sensing platforms, and system integration strategies which play an important role in many mHealth applications.

The development of AI-based healthcare services such as a virtual caregiver system by integrating rules through human-computer interaction can be introduced. This can connect with mobile chat bots or applications that consist of physical, mental and social questions can be developed. With a greater amount of data, we gathered that in today's condition the development of a digital compression

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algorithm that is capable of reducing electrophysiological data needs to be implemented without deforming the original data. The proliferation of wearable devices will provide real-time data that empower them to take proactive measures to monitor one's health. Med-tech companies can now prioritize the security and privacy of users which may speculate the market for mHealth applications and wearables.

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