Impact of the Internet of Things on Psychology

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The Internet of things (IoT) is a network of smart things that can interact without human intervention. The IoT has affected different aspects of human life and led to the Fourth Industrial Revolution. Psychology is an important area of human life affected by the IoT. Inner peace has always been a human concern, for which the principles of psychology must be analyzed and practiced. IoT technology has come to the aid of psychologists in analyzing and resolving prominent psychological problems.

1. Introduction

The introduction of the IoT in psychology can help promote mental health by providing certain advantages such as accelerating treatment procedures, reducing healthcare expenditure, and improving quality of life [1]. Previous studies have sought to use the IoT for different purposes, such as morale improvement, diagnosis, and mental healthcare.

Morale improvement: The modern world has caused many stressors in people's lives. If individuals fail to manage stress and anxiety, they will soon lose the necessary concentration and energy for their daily routines, and will experience long-term difficulties in terms of both mental and physical health [2]. The pressure from education [3], work [4], and even driving [5] can deprive humans of peace. Different studies have been conducted to improve people's moods through IoT mechanisms in order to help them to cope with mental tensions.

Homework assignments and exams can stress students out, which might result in academic failure. Conversely, studying and doing homework regularly can increase their peace of mind. Virtual Tutor [6] is a mobile application developed to alleviate students' stress and anxiety during exams and homework. Planning a curriculum, this application regularizes the academic affairs of students. It also makes some suggestions to prepare students to follow the planned curriculum, encourages them to continue on the path, and applauds them after they achieve specific goals.

In commuting by car, tardiness and the inability to inform others can stress passengers out. Traeddy [7] is a service that informs those waiting for a driver about possible delays on routes in order to relieve the driver's anxiety. This approach can increase the driver's peace of mind because those waiting will not be worried anymore. The Pen-Pen [8] project sends some notifications to passengers a few minutes before their arrival at a destination to prevent them from passing it for various reasons (e.g., oversleeping or distraction). This approach is useful and relaxing for passengers with low consciousness and who are susceptible to mental pressure.

Smart green space has now gained importance as a component of smart homes. In this regard, Smart Home 2 [9] aims to turn people's houses into relaxing environments by growing plants. The necessary care for the green space with respect to environmental factors (e.g., temperature, humidity, and illumination) is provided automatically and remotely. As a result, there is no worry about taking care of plants when the residents are resting or staying outside.

Diagnosis: The IoT has become significant in psychology through the use of various physiological and environmental devices and sensors to identify different parameters, such as feelings, personality traits, and mental disorders. "Emotion is the name used to comprehend all that is understood by feelings, states of feeling, pleasures, pains, passions, sentiments, and affections" [10]. The Web of Objects (WoO) [11] collects data on users' emotions—including physiological feelings (e.g., different kinds of gestures), textual feelings (e.g., Facebook posts, tweets, and messages), and social media messages (e.g., voices, images, and videos)—to detect emotions. After these data elements are analyzed, users' emotions are detected, and relevant services are activated. For instance, the TV plays family movies for a person away from their family.

Music is a universal language that positively affects stress alleviation, pacification, pain management, and cardiac function [12]. While listening to music via the Smoodsically app [13], users' physiological responses such as muscular tension, skin temperature, and cardiorespiratory acceleration are recorded by biosensors (i.e., devices that measure users' physiological parameters) such as electrodermal activity (EDA) sensors and skin temperature sensors. These data elements are then stored and processed to determine the effects of music on the users' feelings.

"Personality is the set of psychological traits and mechanisms within the individual that are organized and relatively enduring and that influence his or her interactions with, and adaptations to, the intrapsychic, physical, and social environments" [14]. Personality psychology [15] uses the messages and stickers sent by people on social networks (e.g., Facebook) and their online activities to detect their personality type.

Depression is prevalent and dangerous in the elderly, and can cause other diseases such as cancer if it is not treated promptly. In this regard, the scholars [16] proposed a depression monitoring system to diagnose depression in the elderly. Recording the daily activity patterns of the elderly, this system measures their depression level changes and identifies those in danger. This system has been able to identify more than 80% of cases correctly. Postpartum depression is also a prevalent mental disorder that can negatively affect mothers' and their children's behavioral, emotional, and cognitive development [17].

Evidently, mental health has significant effects on all aspects of work, education, and life. According to the World Health Organization, "Mental health is defined as a state of well-being in which every individual realizes his or her potential, can cope with the normal stresses of life, can work productively and fruitfully, and can contribute to her or his community" (https://www.who.int/mental_health/who_urges_investment/en/) (accessed date 15 February 2021). In this regard, the Social Sensing [18] project uses a wearable bracelet to evaluate users' mental health by collecting auditory, behavioral, and environmental data from morning to night over the course of a month. According to the results of the data analysis, there is a significant correlation between a person's physical state and their mental state.

Autism spectrum disorder (ASD) is a neurological–developmental disorder affecting people's behavior and relationships. This condition is characterized by symptoms such as learning disability, bipolar disorder, anxiety disorder, and sensory problems. The IoT-BRB system [19] diagnoses the severity of ASD in children by analyzing the data collected from heart rate, electromyography (EMG), and microphone sensors.

Monitoring: It has always been important to monitor and take care of human health, on which various studies have been conducted, such as looking after patients [20], the elderly [21], and children [22]. Given the effects of mental health on physical health, monitoring is important in psychology [23][24]. Due to their daily hardships, people might not have the time to continuously attend to those who need mental health care. As a result, the IoT has been used to monitor and care for those in need.

In many educational institutions, senior students bully and harass junior ones, which can sometimes discourage newly admitted students. The term "ragging" refers to a series of coercive acts, including abusing, humiliating, or harassing the new students, on the part of the senior students [25]. Anti-Ragging The mobile app [26] protects new and younger students from being bullied. When a student feels in danger, they can press the volume button.

Although many of the elderly suffer from mental and physical disorders, they often live alone [27]. The SAHHc (Smart Architecture for In-Home Health Care) [28] monitors the elderly through cameras installed in different spots at their homes. Image processing is employed to detect different facial expressions, which are then used along with data collected from heart rate sensors and body temperature sensors to detect an individual's status. If the system determines that the individual is experiencing severe pain, their nurses or relatives will be notified.

People with mental disorders often fail to recognize their surrounding conditions in public places. This can increase their chances of having accidents in the street or cause them to lose themselves [29][30]. Using a tracking device attached to a patient with a mental disorder, LoRa [29][30] monitors and records their accurate positions. Moreover, when the patient leaves the monitored area, a notification is sent to their physician or caregiver so that the patient can be guided to a safe place.

2. IoT Technologies Used

Technically, the IoT includes a wide range of computational methods, such as data sensing, acquisition, and processing, system design, service provision, and network management. After summarizing the IoT-based studies in psychology, their technical contributions were classified into system design, data mining, and hardware categories.

System design: "A system is a set of interconnected components that has an expected behavior observed at the interface with its environment [31]". A system design is intended to propose an architectural model for the system. "Architectural models describe a system in terms of the computational and communication tasks performed by its computational elements; the computational elements are individual computers or aggregates of them supported by appropriate network interconnections [32]".

To analyze the system architecture, scholars should determine the system components, their relationships and interaction patterns, and their mapping to physical infrastructure. Technically, most of the previous IoT-based studies in psychology are classified in this category. In this regard, Virtual Tutor [6] and Pen-Pen [8] present standalone applications. IAMHAPPY [33] and WoO [11] have designed knowledge bases to identify and improve users' moods, respectively, through knowledge engineering. Other studies have designed systems with more than one tier.

In the Anti-Ragging app [26], a client–server system with a shared data architecture is proposed with two tiers (mobile and server) to help the victim student. The mobile tier includes an Android application installed on students' smartphones. The students enter their identity and other information when registering with the application. The data are then sent to the server and stored in the database. When a student pushes the volume button on their smartphone, their current location is tracked via GPS. Then, a message containing the victim's current location and identity information is sent to the server. Finally, the server sends a message to the cellphones of all committee members via the Firebase Cloud Messaging (FCM) (https://www.javatpoint.com/firebase-cloud-messaging) (accessed on 15 February 2021) service. The committee members will then be able to see the route to the victim on Google Maps [34].

Data mining: The field of data mining—also known as knowledge discovery via databases, machine learning, and advanced data analysis [35]—has been extensively used in different branches of science, including psychology. With the expansion of the IoT, a plethora of data is generated today, and data mining techniques are widely employed to extract information. The resultant information is used to make predictions, make decisions, and smartify systems [36]. In the following paragraphs, the IoT-based studies in psychology that have leveraged data mining are investigated.

Using data mining, Personality Psychology [15] predicts and identifies users' personalities on social media (e.g., introverted, extroverted, nervous, and calm). This is achieved using users' Facebook information, including messages, stickers, and activities in different groups.

Depression is a highly prevalent disorder that causes considerable complications and has a substantial mortality rate [37]. In the Depression [16] project, the elderly's daily activities and behavior are collected via sensors to diagnose depression. The changes in depression levels are then extracted to analyze the effects of different behavior features on depression and identify the individuals prone to depression. For this purpose, machine learning algorithms (e.g., k-nearest neighbor, random forests, and logistic regression) are used. Finally, the elderly are divided into two groups: those who are prone to depression, and those who are not prone to depression.

Autism spectrum disorder (ASD) is a mental disorder in which patients have difficulty establishing social relationships and interactions, and might have limited or repeated behavioral patterns and activities. IoT-BRB [19] collects physiological and behavioral data from patients via ear-clip heartbeat, electromyography (EMG), and microphone sensors. Finally, the severity of ASD is determined by analyzing data through data mining techniques.

Hardware and signaling: Hardware advances have now resulted in the invention and improvement of various sensors installed on different systems. A hardware system includes electronic components such as boards on which other hardware pieces are installed and interconnected for a particular purpose [38]. Most of the investigated studies of this category used Raspberry Pi and Arduino Uno boards. The Raspberry Pi is a mini-computer with a processor, memory, and a graphical accelerator, and supports different operating systems and various programming languages, such as Python, C, and C++. The Arduino Uno is a microcontroller used to fetch and control sensor signals.

In the Traeddy [7] project, a hardware solution is offered to decrease the negative outcomes of using communication devices such as cellphones while driving. For this purpose, a Raspberry Pi board is connected to a speaker, buttons, and batteries, and embedded in a toy. For user interaction, the input information is received via two buttons (yes/no) embedded in the toy's feet, and the output information is broadcasted as audio via the speaker. The toy interacts with the mobile application via Bluetooth.

Since patients with autism spectrum disorder (ASD) are very much interested in toys [39][40][41], the ACHI [42] project proposes a toy bag consisting of electronic and hardware components, including an Arduino Uno board to fetch and control signals of sensors (e.g., attached gas and three-axis accelerometer sensors) and a Raspberry Pi board (equipped

with a microphone, a VGA camera, and a TFT display speaker) for data processing. The Raspberry Pi board processes and sends the data to the server via a Wi-Fi connection for storing, further processing, and monitoring the patient's status.

The Social Sensing [18] project employs an electronic bracelet to collect auditory, behavioral, and environmental information from users. This electronic bracelet consists of an STM32F405 microcontroller with an ARM-Cortex4 core equipped with an integrated digital signal processor (DSP) module. The STM32F405 microcontroller uses accelerometer and gyroscope sensors to collect the human bodily motion information, as well as temperature, humidity, and illumination sensors to collect environmental contextual information. The outputs of the sensors are then processed by the DSP to obtain the audio social features. An OLED monitor is used to show data as well as battery voltage values to users. An SD card module is also employed for local data storage, and data are transferred to the mobile via Bluetooth.

3. Unique Features

IoT-based psychology systems are based on a variety of features and technologies. The following features were recognized: as the variety of sensors, crowdsourcing, context awareness, fog and cloud infrastructure, and inference and intelligence.

Type and variety of sensors: Sensors are responsible for collecting information from users and the environment. A wide range of sensors have now been invented in general and specialized areas. Most papers were based on sensors for data acquisition. Indeed, a wide range of sensors have been used in IoT-based psychological studies. In this regard, GPS is the most common sensor employed in many projects for tracking users' locations for different purposes. In the Depression project [16] and SAHHc [28], a presence sensor is used for tracking users. Moreover, accelerometer and gyroscope sensors are utilized to collect information on users' movements in Social Sensing [18], SAHHc [28], and SA-IoTBigSys [43].

Environmental sensors include temperature, noise, soil moisture, and illumination sensors, which have been used in such projects as Smart Home 2 [9], SA-IoTBigSys [43], and Social Sensing [18] to determine the environmental status. For instance, Smart Home 2 [9] benefits from the above sensors to control the plants' environment.

Crowdsourcing: With the development of smart mobile devices (e.g., smartphones, tablets, and smartwatches) equipped with a collection of sensors (e.g., camera, GPS, accelerometer, and heart rate sensors), along with the prevalence of Internet Wi-Fi connections, there is now the opportunity for crowdsourcing (also known as crowdsensing) [44]. By employing these devices, users can sense and share a variety of necessary information about a population or an environment with minimal infrastructure investment. In psychology, crowdsourcing can be employed to collect and analyze cumulative data on the personalities, mental states, and mental disorders of people in a society. For instance, Personality Psychology [15] benefits from a user's texts, stickers, and activities in different Facebook groups to detect their personality type. Additionally, crowdsourcing could be leveraged to analyze and predict personality types of different communities. Assessing and comparing different genders' personalities in a community is also possible. Likewise, crowdsourcing can be added to the WoO [11] (detecting people's emotions) to determine and analyze the emotions of people of different ages in various communities. It is also possible to investigate the effects of environmental and geographical parameters on the personality types and emotions of community members. This paradigm can also be employed in the IoT-BRB system [19] to evaluate the severity of autism in different communities based on genetic factors, environmental conditions, and social parameters. Nevertheless, before using this paradigm, scholars should solve the privacy issue for people to participate in this process. Otherwise, as psychological information is confidential, people would not be able to contribute to this process.

Context Awareness: In new computing models (e.g., pervasive computing), smart applications collect information about users and the environment through different sources, such as sensors and smart infrastructure [45]. By being aware of this information, called context, applications can provide users with smart and context-aware services [46].

Fog and cloud platforms: As a huge computational and storage resource, the cloud is able to support applications and systems. In general, the cloud is employed to execute massive computing applications (which are impossible to run on users' mobile phones), store big data, and share data. SAHHc [28] has a massive image processing component (to identify the faces of the elderly), which is hard to run on smartphones. As a result, it is offloaded and executed on the cloud. Moreover, in the Postpartum Depression (PPD) project [47], hospitals and medical centers use a private cloud to store pregnant women's medical records. Therefore, gynecologists can access the files of their patients if necessary. In Smart Home 2 [9], the cloud platform is employed to store information on the equipment and sensors of smart homes. Users and applications can access the cloud to meet their needs through smartphones and web browsers.

Inference: Inference is an artificial-intelligence-based approach to data analysis for acquiring high-level information. Sensors can only measure simple data [44], and are unable to measure high-level information directly. Under such conditions, an inference component is used to extract high-level information from low-level elements. For instance, the daily behavior of the elderly is collected through sensors in the Depression project [16]. Using these data elements, the changes in depression levels are inferred to identify the individuals who are prone to depression. In SAHHc [28], the recorded images of the elderly are processed to infer their emotions and provide appropriate services accordingly. For instance, when a feeling of pain is inferred from an old person's face, the system informs their physician or caregiver. Finally, IoT-BRB [19] evaluates the severity of autism by collecting physiological and behavioral data from patients via microphone, heart rate, and EMG sensors, and analyzing the data.

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