

Inspiration and Defies of IoT-Empowered Augmented Human Devices for Independent Living

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Abstract

Engineers make the world; Engineers support the world. Engineers pillar of the world. These short definitions are ensuring the importance of role of engineers in updating facilities to make the sophisticated world. The creation of sophisticated world includes fulfilling the implicit and explicit needs, stated and unstated needs make human life easy by innovation and fulfilling dreams that is make them super heroes. Yes, what human dreamed, are come in alive by internet of things empowered devices. The role of IoT-Empowered Augmented Human is augmenting human abilities or lifestyle by means of IoT devices. Generally, such augmentations are broadly classified in to three aspects viz. enhance the physical power of the human, augmenting the sensing ability of human and boosting cognitive performance. This ample survey focuses on sensor devices for IoT-empowered augmented human. The objective of the survey is to identify the potential challenges and research opportunities. The IoT-empowered sensor devices for augmented human are discussed in detail, and discussed the identified defies.

Keywords: IoT, Augmented Human, Human Life, Independent Living, sensing ability, lifestyle, defies.

1 Introduction

Internet of Things plays vital role in prevailing over the nowadays changes and creating wonder facilities and products. In particularly IoT bump up abilities of human, fulfilling his disabilities in association with human augmented technologies and enriching his quality of life. This work makes sincere effort to addressing the prospective defies which connected with IoT-empowered Augmented Human (IEAH). IEAH can be explained that it is branch of IoT which commonly employed with wearable electronics with division of communication defies in reliable way for comfort of human/ user. Though it is advanced technology one must be trained or the operation must be simplified through user friendly system like mobile app controlling the air condition or television [1]. IEAH is bio-integrated which relies majorly with communication technology and operated with aid of interconnected device of IoT. Such IoT device usually preferred a highly heterogeneous Body Area Network (BAN) to use supports and update software and other tasks for the system but it will work in internet connection [3]. Reliability of such system is highly recommended because even

its communication failure or irresponsive system degrades cognitive as well as physical abilities and makes human Defenseless and mentally depressed or it would cause pandemonium [3]. Like engineering change of industry 4.0, the medical sectors have Human 2.0 which focuses human augmentation efforts in terms of cognitive furthermore physical through implants, artificial aids specially designed for replacing hand, leg, etc supporting aids for enhancing human vision, hearing, etc. [1]. The IEAH ability is performed two aspects. They are substitutive recover and empower augment.

2. Role of IoT- in IEAH

IEAH is applied for substitutive recover and empowers augment. [2] explains that the IEAH turns the perfect human to super human as well as support to physically challenging human or who lost his physical abilities by accidents by fulfilling his inabilities (substitute recover). That is IEAH can be altered as and when required as per the quantum of need in specific beyond the natural capability or uplift to natural capability (Refer Fig. 1a). The IoT substitutive recover of physical augmented human recovers physical inabilities like loss of leg or hand or inability to move etc.

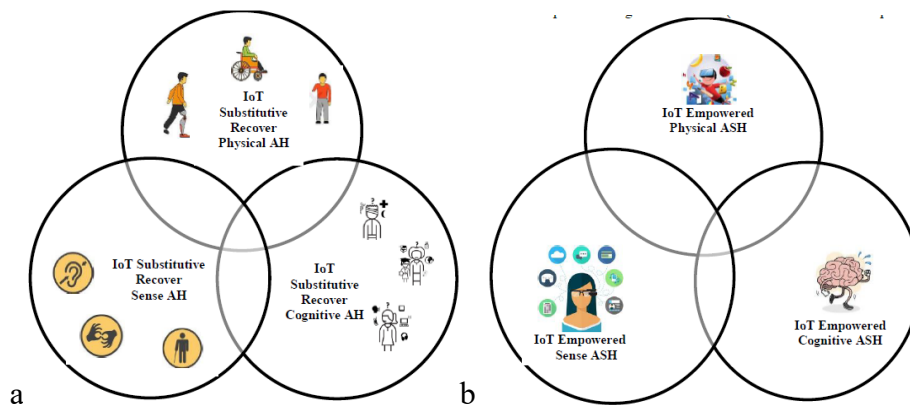


Fig. 1. IEAH (a) substitutive Recover for specific need (b) for super human needs

The IoT substitutive recover of sense augmented human includes deaf, dumb and blind recoveries and the IoT substitutive recover of cognitive augmented human includes recovery of permanent, temporary and situational cognitive disability. The Figure 1b illustrates IEAH of physical, cognitive as well as sense augmentation for human who has usual physical, sensual and cognitive ability and imbibes the ability to meet the super human needs

The Miniature sized e-devices which designed to amplify the ability like hearing aids, AR spectacle are best example for augmented human. The applications of IEAH broadly classified in to three classifications namely augmenting intellectual abilities that is mental abilities like support for planning abilities, through decision making, data processing etc., (parking space availability check, road map application like goggle map, timeline updates etc.), augmenting physical abilities like artificial leg, arm etc. and augmenting sensorial abilities like vision, hearing, touch etc.

3. IEAH devices for supporting living

Internet of Things (IoT) can be defined as a smart device which connected is a network either by cord or cordless for the purpose of to collecting data and enable a real time communication between people and devices [4]. The sensors played wide role in monitoring, manipulating and accumulating data in IoT devices from physical world into internet [5]. The IoT plays important role in developing smart environment /cities [6-8], establishing smart transportation [9], online health care [10], smart weathers [11], smart grids [12]. The integrated smart environment is clearly illustrated diagrammatically by [3] is presented in figure 3[3].

3.1 Online health Care

- On line health care is a part of smart cities moment [13, 14]. It consists of Electronic health (E-Health), Mobile health (M-Health), Smart hospitals (S-Hospital) and Smart health (S-Health).
- Electronic health (E-Health) is absolutely ICT (Information and communication technologies) based establishment to assist the patients by suggesting, homecare, nearby facility etc and also trimming down the cost acquired by measures for monitoring technologies and for preventing respective health issue through IoT devices. [14,15].
- Mobile health (M-Health) is a patient oriented model as well as part of online care which helps to identify the available facility near him and other related information like facility available time, contacts, route map to reach etc through mobile App. It also supports the patients to stronger in competence of indoor monitoring and premature sighting of crisis condition and anomalous situations [16, 17]. This facility including ordering medicine over online to medical shops for door delivery.
- Smart hospitals (S-Hospital) connect the physician with patient if required adding specialist on patient's infirmity concern in online for consultation [18]. The conventional interactive environment is shifted to online by adding the high-end omnipresent devices which reduces the time of travelling, waiting uncomfortably at hospital [13].
- Smart health (S-Health) is a city oriented model integrated model of sensing competence of smart cities and m-health features [14]. In this system the source and flows of information from the government's data sources.

3.2 The Defies:

- Most of the death causing the time elapsed in travelling, waiting etc. to reach physician care. This can be avoided by integrating the facilities like scan centers, labs, medical shops, clinics, blood donors, plasma donors etc., near patients and physician through IoT devices.
- IoT system also must support to meet the emergency requirements like first-Aid and taking any medication before reach the hospital physically.
- IoT devices shall integrate the periodical check up for slow recovery cases at home care with local testing labs/ nearby health care centers



Fig. 2. IoT-empowered integrated smart environments [3]

4. IEAH devices for supporting independent living

Every human live by playing various role in his own life with same human body by intention or necessities. They are spiritual life, /Personal life, professional life and social life. He needs to satisfy himself and concerned person through his wellbeing. Now the role of IEAH supports to play his roll well can be discussed. Nowadays IEAH technology assists to whom living dependent. The dependent living people are those either aged, physically impaired, who lost their of body parts by accident or by disease. By the way IEAH technology helps them to fulfilling certain daily routines, assisting to acquire basic needs independently. Secondly the IEAH technology facilitates for enhancing his professional performance (e.g. preparing and processing documents at specific form with advanced features or enabling him to perform professional activities like others (blind man makes call/ Voice messages through smart phone). Thirdly helps him for enhancing self efficiency, getting relaxed through entertainment like online gaming. Though it is not primary need the innovative and advance feature attracts the human beings more (e.g., smart phones) irrespective age group. Hence IoT plays the role of fulfilling the social and ethical characteristic requirements. Nowadays internet based human machine interaction is indispensable task in day today life. Though certain classes of people (e.g., aged, illiterates etc) are feeling less comfort while train them to interact. They are eager to learn and use due to attractive features of IoT devices. IoT devices established a sophisticated world (e.g. IoT devices in build Car, Travel bus, TV, music, money transaction, shopping, teaching, booking tickets, food, hotels etc., from the above it can be understood that IoT creates smart and integrated environment for his living.

The approximate statistics of disabled people around the globe are 466 million are suffered by hearing loss, the deaf and dumb are 9.1 billion and 1.3 billion are vision impairment in which mild and moderate vision impairment are 188.5 million and 217 million respectively and blinds are 36 million [19]. Adults suffering by hearing loss (hearing loss>40 dB HL [20] . by age factor is escalated [21]. usually starts at the age of 40 years and escalate gradually and steeply after 80 years age of in human body. Age-related hearing loss is a serious issue which restricts quality of life and affects mental health significantly by unsuccessful social linguistic communications and social engagement [22]. From the above statement it was estimated that 30% of people aged 65, 65+ are suffered by

Deafness i.e., Age-related hearing loss alone in 2012 [23] and forecasted that at 2030 the deafness would be top 15 leading burden diseases [24]. The demand for high-tech wearable aids for compensating the hearing loss which connects online health care centers would be increases significantly [25].

Sign language is mostly employed among disabled peoples. IoT empowered sense based augmented human devices for substituting recovery, usually the gesture recognition is carried out through vision based or data glove based [26]. [27] developed an IoT device for disabled person which detecting sign languages and translate in to speech. [28] used optical character recognition to covert text in speech. Translating the sign languages by recognizing commands and characters [29] used the flexi sensor by in the hand clove and delivered in form of audio visual by means of LCD and Bluetooth speakers. Based on the bending of the flex sensors, the output the characters formed [30]. The VSS pins provided for ground and power supply, the write and read pins provided for writing the values on the LCD display [31]. The flex resistance maps to character and its data connected to audio output via Bluetooth [32]. Usually Global System for Mobile Communication employed voice transmission, etc. This system uses GSM (Global System for Mobile Communication) model for voice and data transmission which operates at a varying frequency band. It is used to receive, send or delete messages in a SIM [33]. [34] developed a neural network model namely Efficient and Accuracy Scene Text detection Pipeline for text algorithm in which RASPBERRY PI B+ Model and ARDUINO UNO micro controllers are used. [35] developed Raspberry Pi and Google API aided IoT device for supporting the blind deaf and dumb by which they can read message through audio output by capturing image by blind, which also support to covert audio to text for dumb people. Blind musicians compromised their vision impairment through prototypes like smart phones for indentifying the patterns and for image processing [36, 37]. A variety of hardware and software are exist to support read and write activities in which Braille systems employed for machine vision or computer vision[38]. Multi User Dimension (MUD) devices are text based AutoMUD devises are multiuser virtual device for blind [39]. [40] proposed that fisher faces algorithm by which be familiar with people's faces and can identify a person all the way through aforementioned system training, the obstacles detection by blind by means f uses ultrasonic sensors to generate vibration signals, email reader by POP3 protocol and , MP3 player for entertainment. [41] introduced a wearable device for deaf-blind called 'GlovePi' which recognized the person, his position of people (Standing or sitting) facial expression etc who in front him. [42] introduced a mouth gesture recognition system to collect data from the dumb. [43] used Sharon Bridge philosophy which tested to convert American sign language to audio by which various disabled peoples exchange their messages. Apart from this some of the challenges still exist.

The Defies

- The complex algorithms employed for data processing and noise interference are defies in preparing the appropriate output related issues in vision-based techniques. The background containment and dissimilarity of lighting conditions are defies in image and video processing [44, 45].

- The live tracking and optical character recognition must be incorporated in IoT empowered sense based augmented human devices which purposely designed for converting sign languages to speech for enhancing system performance [46].
- Share location Alert option by operating a button must be offered in the system, by which the blind person shall share his location in case of emergency [47,48]
- The size and weight of battery important factor in designing wearable IOT devices quite simple and soft [49]
- Just adding extra fittings in the human body for sensually disabled human is not sufficient it should be client concerned technologies and interfaces [44, 50, 51]

5. Prerequisites for successful IEAH Devices

5.1 Design Aspects:

Customer requirements are influencing more in defining the prerequisites any products. But in designing the IEAH Devices many factors are influencing.

Bulkiness of the Device

Miniaturization is highly recommended. The sophistication and comfort of using IEAH Devices increases while its size decreases. In such devices the nanotechnology plays vital role in designing electronic components [52]. As materials like nano-grapheme supported nano-antennas make possible the communication in the range of frequency in tetra hertz, it is preferred for designing such electronic components like receivers, sensors, processor [53-55], antenna, transmitters [56] actuators [57] etc. but limited distance of communication [58,59] to maximum 2 meters and further such distance is reduced a quite a lot of millimeters in the medium of liquid which has high concentration like human bio fluid [60]. So, it would support the human body integrated IOT devices.

Trustworthiness

As the IEAH Devices are employed for mission-critical application the trustworthiness is one of the important criteria. [61] complaints that predominantly the devices released without checks its trustworthiness and accurateness. [62] supports for above statement and justified after verifying the accuracy of wearable devices that the marginal variability of their accuracy till 25%. The trustworthiness of IEAH Devices are not only concerned with device but also including cloud server performance and quality of server platforms [63]. [62, 64, 71] also stressed the importance of trustworthiness of such supporting systems by highlighting significance of their failure, [63] also suggested the placement optimization.[63]

Energy Demand

The energy demand in the IEAH Devices generally associated with its efficiency in transmitting as well as harvesting energy [65], and recommending low frequency in recharge or replace battery cell.

Synchronization

This requirement meant harmonization in accuracy, efficiency and energy. There must be a better trade off among them. As the IEAH Devices are employed

for mission-critical application such performance needs to be defined and avoid ambiguity [03].

Fitness for use

Some of the defies in design IEAH Devices for specific use. For example, consider a case of design a hearing aid IoT device. In this case ear hole size and shape difficult to standardize. One must accommodate the nano-components, facilitating security, networking access control etc. with the fabricated shell for that human ear hole size and shape. Many literatures highlighted this kind of issues. Many defies are there to translate the theoretical design to actual product.

Employing Flexible Hybrid Electronics

The kind of kind of electronics in thin material with electric circuits, which offers flexibility like elastic material that is either it can be bend or stretch, conformable as well as disposable, weighing less, is often referred as Flexible Hybrid Electronics (FHE) [66]. They offer better performance than conventional bulky, rigid electronics [67]. The advanced soft and strong materials enable integrating various electronic systems to achieve desired design and wearability of IEAH Devices for specific use [68,69]. Some of applications highlighted in the literature are: bio friendly materials made FHE devices are employed in biological tissues like internal organs, skin etc. [70].

Energy and Efficiency augmentation

As IEAH Devices wearable, the mass and dimensions of the replaceable or rechargeable batteries are important criteria in design [71]. The other criteria are life time of replaceable or time between recharge. Sometimes such measurements are considered in terms of number of operations [72]. Customer expectation highlighted by [73] that auto-recharge or no recharge, less maintenance or zero maintenance [74], life time energy efficient power units [75]. [76] estimated overheads for networking in IEAH Devices. The wearability requirements were derived by [77]. BAN based network algorithm supported well in augmenting the efficiency of network by diminishing its overheads [78]. Pareto Principle based Approximate Computing (AC) offers extreme enhancement by capture 20% data and facilitate for 80% application performance that is reduces noises in IEAH Devices considerably.

5.2 Connectivity Aspects:

IEAH Devices are generally preferred promising networks like 4G, 5G and its emerging advanced versions for achieving best outcomes in augmentation or supporting tasks. IEAH Devices stipulate Body Area Networks including inter and intra category, its architecture, its physical interfaces.

Communication Network

As human live on the multiple connectivity environments like 2G, 3G, 4G, 5G, 5G+ etc., the sustainable operation of IEAH Devices must adopt the best available connectivity in the Multi-tier networking architecture [79]. The intra body area network communication employed for amalgamating the all-personal devices into a network. As liability of any particular device does not affect the entire body area network in distributed body area network approach, It is preferred

than orchestrated body area network [80]. But the orchestrated body area network is promising enhanced energy efficiency and quality of service [81-83].

The role of inter body area network communication is connecting multiple devices for interaction and facilitating for harmonization in the middle of IEAH Devices when clients work together. The inter body area network communication is generally typified by a superior chronological and spatial active. Some of the stability issues of the session outages and link obstructions can be conquered by establishing the communication links by the use of supplementary robot relays. This can be understood with working of drone [84]

Cord and cordless infrastructures

Cord infrastructures offer better quality, reliable and consistent connection and they are preferable for connecting decisive components of IEAH Devices. They are practically less invulnerable to radio interventions, more accessible distance for devices, and can be utilized to provide energy to devices, etc. So cord type infrastructures are preferred for intra body area network, and they connect fixed components as well as connect components those permitted [71].

Though cord infrastructures have significant advantages, they are less flexible than cordless interfaces. Cordless interfaces can be used for both intra and inter type body area network communications. The mobile networks and Wi-Fi are usually employed for intra body area network communications. Wi-Media, Zig-Bee, Bluetooth, are employed for inter body area network communications [85]. The molecular communication is best example for advanced intra body communication technologies in which tissues of human body employed as a transmission medium [86, 87]

Performance augmentation

Network traffic rapidly increasing day by day due to increase of number of connected devices in the network, increases the add on facilities and decreases of size of device designed for comfortable wear. For example, hearing aid used to connect the phone calls, all phone related audio outputs [88]. Add-on facilities shall be increased, high data requirements to connect cordless wearable devices in future leads to dense deployment and becomes more traffic that is primary concern is interference. The performance augmentation is indispensable to ensure the performance of IEAH sensor Devices becomes more challenging assignment. [88] proposed millimeter-wave links in place of microwave spectrum as an alternative in wearable networks for avoiding of larger signal loss by the higher spectrum [89].

Advanced Connectivity

Need for the advanced connectivity like 5G/5G+ widely stressed in the literature for manufacturing [90], medical facilities [91].and for transportation [92]. The advanced connectivity facilitates to shift back to homogeneous network, better control over traffic, etc. The advanced connectivity unlocks new prospect for IEAH sensor Devices by fetch a substantial change in the quality of services contribution Ultra-Reliable Low-Latency Communication (URLLC) for delay-sensitive applications. As IEAH sensor Devices are wearable, they demand

advance connectivity to manage the high degree of temporal and spatial variations [93].

The defies

- The system must support consequent splitting and merging of IEAH sensor Devices comfortably as required by the users.
- Some of the advance options are to be enabled like searching nearby devices, searching available networks, unlock heterogeneous gateway to join devices by means of various radio admittance technologies.
- The system and its connecting networks must be human friendly that is does not cause for any health-related issues.
- The THz communication and millimeter-wave high frequencies support BAN Directional wireless communication by operating emerging air interfaces [89, 94].
- The IEAH sensor Devices must have Adaptive network management mechanisms to facilitate real-time network adjustment to unreliable demands.

5.3 Security Aspects

Human Security

- As IEAH sensor Devices interact with the body, the must adheres security standard established commonly for worldwide [95-97].
- Infected by virus and other kind of threats must be controlled or solution must be established.
- Hang of system due to jam of radio frequency jam, and other kind of blocks shall be tackled easily like restart of the system.
- Cost incurred due to excess energy consuming when operating frequency high must be indicated to prevention of system failure. For example, alarum must be there before the battery going to down but the system must work at least a day or half a day. That will enable to plan to carry the spare battery.
- IEAH sensor Devices must free from hackers' attack [98].

Cyber Security

- The security issues associated with connected network and its message authentication code on IEAH sensor Devices must be resolved [98-101].
- The vulnerable to tampering and cloning must be identified by vertical identifies like message authentication code (MAC) or International Mobile Equipment Identity (IMEI) [103-106] or by a hybrid identifier [102] to block the un-trusted devices.
- Diminishment of attack while accessing the network like traffic burst, de-synchronization, Sybil, spoofing, signaling storms and tampering server or client interface [107] For example IEEE 802.15.6 secured devices at three levels like basic security at level1, providing authentication for enhancing security in level 2 and enables authentication and encryption in level 3 [108].

App Security

- Many un-trusted sources are offers software illegally, they insert logical bombs, sniffing, malicious code or Dos attacks be able to build the client susceptible.
- Such attacks take advantage of usual inability of human being and make easy for hackers.

The defies

- Prevention of social engineering attacks by use of machine learning algorithms for monitoring and providing an active protection [108].
- Facilitating to validate the designed performance like security scan for identifying the vulnerable threats and clean them.
- The system must block the installation of software from un-trusted sources.
- The system must block the connecting un-trusted devices

6. Conclusion

The IEAH sensor devices are great blessing to human being. Such devices offered great support in augmenting abilities of human being. Though human ability augmentation is multidisciplinary, this article especially surveyed with the focus of sensor devices for IoT-empowered augmentation of human ability. There are three kind of support to compromise the lack of physical ability of human. The first is alternate support, the use of alternate sensing ability to compromise some complete physical inability of human, for example samsung developed good vibes app by which blind and deaf human can communicate through exchange of messages, in which ‘Morse codes’ employed for converting voice or text messages to vibrations vice versa. The use dashes and dots to post the message which will receive in form of voice or text. The blind / deaf are able to understand ‘Morse codes’.

Another is augmentation of lack of physical ability of human by amplifying the sensing ability. For example, the app - Relumino released by Samsung support the human with low vision to see the image well by either turn on negative/ dark mode or fine-tuning of contrast brightness and colour, highlighting the image outline and expanding and decreasing images.

Third kind is saving or magnifying human ability over sensor example, online meeting apps, and video calling in mobile phones. Highlighted examples are mobile phone oriented. Such augmentation expected all other IEAH sensor devices including their autonomy and offering advanced services. Sensor based this ample survey addressed research and development opportunities.

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