International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Context Based Computing:
A Survey with Wearable Devices

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ABSTRACT

The body worn devices which can augment and extend the capabilities of the wearer are wearables. It is required that a wearable should work in accordance to the context of the wearer and his surroundings, in totality it is considered as Context Aware (CA). The context can be detected by means of sensors attached to the device and other user related information like calendar and social sites. The sensors generate raw data, which is further required to be processed, analyzed and reason for getting real context, this is termed as Context Detection. An exhaustive survey is done in the field of wearable and the Context dimensions required for detecting context. A brief history of wearables with the challenges involved in this research arena has been covered. This paper also focuses on the different perception of context provided by various researchers and tried to find out the most suitable dimensions with respect to wearables. The paper is suitable for both the novice user and the research oriented people as the maximum aspects of wearbles and Context has been covered.

Keywords *–* ***Context Aware, Context Computing, Context in Wearables, Wearable Computing***

I. INTRODUCTION

The technological advancement has reduced the size and increased the capability of computers in such a manner that it has given the birth to wearables. These are small body worn devices which can be used to assist us in our day today activities. They are the demand of today and the future of tomorrow as they are becoming an integral part of our daily outfit. If we want that the device (wearable) should anticipate as the user wants and without his much intervention, then comes the "Context" concept. 'Context-Aware' term was first used by Schilit and Theimer [1] and referred as location of use, various nearby objects and people, and changes to those objects. Computing based on context awareness is well utilized in mobile and ubiquitous computing and we believe that it can find application in the wearable paradigm too. This survey focuses on the wearbles and the identification of CA associated features & parameters for an ideal wearable.

The paper is organized into various sections. Section II provides survey on wearables. In this section the focus is on its history, definition, challenges involved, application domain and its Market Prediction. Section III covers the review work on Context awareness, various dimensions of context and their relationship. Section IV is the Finding & conclusion part.

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II. WEARABLES- A REVIEW

By hearing the term "wearable" mostly people perceive fitness trackers and smart watches, but the history starts from hundreds or thousands years back with Tattoos (body piercing) and jewelleries (body worn ornaments). Then arrives Chinese abacus ring [2] in the Qing Dynasty era (1644-1911), it was a wide ring worn in the finger of user and can be used as an abacus.

In 1890 Illuminated ballet girls [3] were introduced, in which the dancing girls wore electric lights on their foreheads and batteries in their dresses. Cheatin' Shoe [3] was introduced in 1961; it was a timing device attached in a shoe for predicting the landing position of the ball in a roulette game. TV glasses, calculator watch and portable stereos in 1970s were other revolutions. A lot more happen in between. Father of wearable computing, Steve Mann defines wearable computing [4] [5] with three main properties, first it can be worn like cloth, second it can be controlled by the user, and, third it can be used in real time i.e. it is always active.

It is defined by Barfield [6] as "fully functional, self- contained portable computers which are worn by the users on their body". When wearables interact with the environment users can access its computational power for their use [7]. They are un-obstructive intelligent embedded system, which can sense environment and suitable for mobile users. Levis ICD Jacket, Bluetooth headset, Nike+, FITBIT and Google Glass were gift of early 2Ks and Apple Watch, Ringly, Quell, bPay and Oculas Rift of late 2Ks. A general architecture of wearable can be viewed as shown in fig. 1.

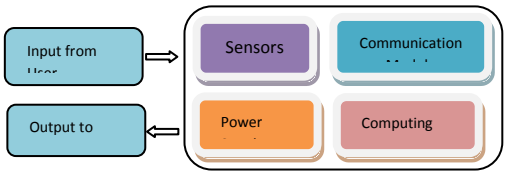

Fig. 1. General Architecture of Wearable

According to Thad Starner [8] an ideal wearable should have these properties: persists and provides constant access, Senses and models context, Augments and mediates, and interact seamlessly. The various properties of wearable is shown in fig. 2.

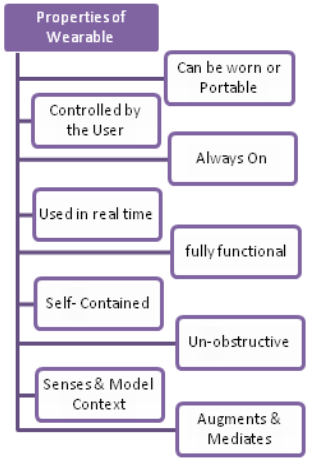

Fig. 2 Properties of Wearables

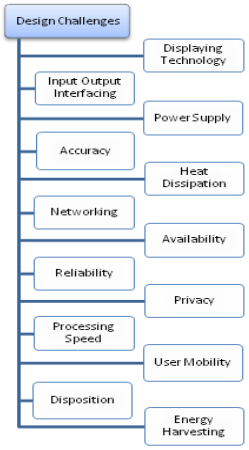

Fig. 3 Design Challenges Involved

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

The main issue comes while designing wearables. The design issues [7] for wearables are mainly related to displaying technology, the type of input and output devices can interface, low power consumption and image registration for further reference. Various challenges involved in wearables are explained in [9][10] mostly it covers Power, Heat Dissipation, Networking, Privacy and Interface Design. Criteria like availability, reliability and form factors like weight and volume are included as design criteria by Plessl, et al. [11] and solved the problem of high performance requirement for operations like video decoding with minimum energy consumption by using reconfigurable hardware i.e FPGA. A model has been proposed [12] for the systematic design of wearables with respect to its architecture. In this model various factors has been considered like ergonomics, the device placement requirements, and dynamic workload profiles. One general purpose computing module, Q-Belt-Integrated Computer (QBIC)[13] is designed by considering the criteria of lower energy requirement, higher processing rate, ergonomic form factor, scalable connectivity, extendibility and reliability. The problems because of user mobility like dynamic variation in number and type of devices for interaction, has been considered [14] and Voyager a development framework is implemented which helps in creating distributed human interface.The tradeoff between prediction of accuracy and consumption of power is analyzed [16] and selective sampling collection strategy is proposed to increase the lifetime of deployed wearable. How an accelerometer can be used in wearable [17] for finding context is assessed for various fields by placing it at different parts of body. The user can wear or put after use his wearable device at several different location, or he can change his pose while use this is termed as disposition [21]. This disposition can be one of the design criteria of wearable and can be used to determine the user context. The most important requirement of wearable is power supply; this is done by using rechargeable batteries, sometime it is not possible to charge due to unavailability of power supply or users forgetfulness. An alternate method has been found [22] for these problematic situations by harvesting the energy from human motion like walking, running, going upstairs etc by putting embedded harvester in a shoe. A similar method of energy harvesting [23] by the combination of vibration of body, electromagnetism, and the piezoelectric effect that is generated by human body due to their daily activities has been developed as a prototype called as WE Harvest. The various design challenges and other issues are summarized in Fig.3. If we talk about wearable's forecast then Transparency Market Research, an U.S.-based market research company, says that the global market for wearable technology can increase from US$750 million (2012) to US$5.8 billion (2018) [32]. There is another forecast by Good Intelligence [33] that there will be 604 million users in wearable biometric technology.According to [32] Wearable technology market segment is divided into 4 main parts: Fitness & Wellness, Infotainment, Healthcare & Medical, Industrial & Military. The various application areas where wearable can be used as per [7] [34] [35] are Medicine, Manufacturing or Industry, Architecture, Face Recognition, and Intelligent or Personal Assistant. The purpose of wearable cannot be fulfilled if the system is unaware of the context of the user. Early work of Schilit [37], defined three main aspects of context as: "where you are, who you are with, and what resources are nearby". There are various other ways to find context. Various researchers have provided different dimensions for finding context. The next section covers the review of the work done in the field of context awareness and its fundamentals.

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

III. CA –A REVIEW

Researchers are working in the area of context awareness since more than one decade. The word Context originated from Latin which signifies how something is made. As per oxford dictionary it can be defined as "the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood". Various researchers have perceived context in different manner and they have provided different dimensions for its detection.

As per Schilit [37] context not only encompasses user's location, but it also includes lighting, level of noise, connectivity with the network, cost and bandwidth of communication, as well as the social situation; for example whether we are with our peer group or with our senior. It can be divided into three different context types as: First Computing context considering network connectivity, communication cost & Bandwidth and nearby resources; Second as User context taking into account user's location, nearby people and social situation and third Physical context comprising of noise level, lighting, temperature etc.

Brown et al. [38] define user's present context as their location, who they are with, time of the day, temperature and season etc. Dey [39] enumerates context as information which is attended by the user, his mental (focus of attention) and emotional state, location and orientation, date and time, and the nearby objects and people in his surroundings.

The definition of context which is provided by Dey and Abowd [40] describes context as "Any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves". So from this context can be perceived as any piece of information which can be used to describe the situation of a participant involved in an interaction. This makes the definition blur as it is considering everything which surrounds the object of enquiry.

Dey [40] defined context aware as "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Context awareness can be perceived as sensing the data, interpreting and using it for adapting the application as per the context.

Chen and Kotz [41] not only considered the above three context categories considered by Schilit [37] but also added one more category i.e. Time context as fourth category and defined the context with respect to mobile communication as "Context is the set of environmental states and settings that either determines an application's behavior or in which an application event occurs and is interesting to the user". They have differentiated context into two different group active context and passive context. Active context is automatic adjusting the conduct of application as per the context determined by the application on the go and furnishing the context to the user and passive context is storing the context for to be fetch later by the user.

Only focusing on the physical world for mobile and ubiquitous computing it is defined as "Context is what surrounds" [42]. In a simplified manner it has been described by Abowd and Mynatt [43] as we have to include not only where (location) and who (identity) but also when (time), what (focus of attention) and why (effective state). Based on users activity [44] a cognitive based model is provided for finding context termed as activity centric context.

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Context aware applications works on various service logic which can be perceived as Presentation logic (showing context to the user), automatic execution logic, and attaching context logic (for lateral retrieval of information) as per the input provided by end users[45].

Considering Functionality & power-packaging for wearables, Bharatula & Paul [46] considered the activity of the user and the situation which surrounds him as context. A reasoning method based on Information gain [47] is used for finding context from low level context to high-level context. Low-level context are directly determined simple context from sensors, whereas, high-level context can be inferred from low level context as a meaningful abstract. Haesung Lee, Joonhee Kwon[48] has emphasized the emotional status as a human context which is overlooked by other researchers in finding context for wearable computing.

Jiehan Zhou et al., [49] define context as "Context is any information characterizing the situation of a task session or interaction between a user and his/her service world. Context is categorized into user context, peer context, process context, physical context, and service context". Here user context means the habit of the user, his emotional state, social environment and the task performed by him. Peer context is related to the service provider context which include service providers role. Process control is about initiation, controlling and maintaining of tasks sessions. Physical context implies the environmental data like location and physical conditions i.e noise, temperature, lights. And the last service context is related to technical and managerial information like network connectivity, communication bandwidth and its cost.

With respect to ubiquitous computing [50] Zhang and Huang categorize contexts into two parts i.e physical context and virtual contexts. They refer physical contexts as the context which can be bundled from sensors like acceleration, light, air pressure, location of entity, sound, temperature etc. and virtual context as the context which is specified by the users or invaded from interactions of user, it also include the choices of users, his goal and business tasks.

Table I presents the context perception of different researchers and their relationship with their provided dimensions. We have used ordinal measurement scale, where 1 represents considered and blank represents not considered for defining context. We have covered 16 different types of dimensions as per the definitions provided by researchers. Few of the context dimensions overlap as they are stated in a different way but they mean the same, for example low level context means the context identified by the sensors they can be perceived same as environmental and location context. But we have not overlapped them in our paper and considered them differently as per their definitions. This gives the readers a clear view of context as per original.

This shows that most of researchers have given maximum consideration to physical, location, time, nearby resources and activity performed by the user for defining context. Some of them have considered the mental and emotional context type, while some have used the low level data to find out the high level context, very less have talked about emotional, service and process context.

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Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

TABLE I Different Context Perception and Their Relationship

Context Type → / Paper Title ↓	a User	B Computing (N/W, H/W,	c Physical	d Social	e Who	f Where (Location)	g When	h What (Resources	i Nearby	j What	k Why	l Emotional	m Mental	n Network	o Internal Dimensions	p Low Level (Physical	q High Level	r Virtual	s Peer	T Process	u Service
Disseminating active map information to mobile hosts (1994) [1]						1		1	1												
Context-Aware Computing Applications (1994)[37]	1	1	1	1	1	1		1	1												
Context-Aware Applications: From the Laboratory to the Marketplace (1997) [38]			1			1	1		1												
Context-Aware Computing: The CyberDesk Project (1998) [39]						1	1	1	1			1	1								
A Survey of Context-Aware Mobile Computing Research (2000) [41]	1	1	1				1														
Multi-Sensor Context-Awareness in Mobile Devices and Smart Artifacts (2002) [42]			1			1															
The Human Experience (2002)[43]					1	1	1			1	1										
Activities, Context and Ubiquitous Computing (2003) [44]			1							1					1						
Functionality-power-packaging considerations in context aware wearable systems (2006) [46]			1							1											
Context Selection and Reasoning in Ubiquitous Computing (2007) [47]																1	1				

Combining Context-Awareness with Wearable Computing for Emotion-based Contents Service (2010) [48]												1									
Context-aware pervasive service composition and its implementation (2010) [49]	1		1	1		1													1	1	1
Survey on context-awareness in ubiquitous media (2011) [50]			1															1			

IV. CONCLUSION

This paper presents the survey on the context based computing with wearable devices. As wearables are becoming our day today outfit, it is important to make them aware of user context. The context is everything which is related to user and the application. It can be environmental data, user location, his preferences, social interaction or his mental or emotional status. It is very difficult to incorporate all dimensions of context in a wearable, keeping in view the design criteria, properties and networking criteria of wearables,. There is a huge scope in finding up-to-date, accurate, and complete context in wearable by using the context dimensions provided by various researchers. New researches in this field can incorporate some of these dimensions and move forward in context aware wearables. They can focus on the dimensions which are mostly considered or they may touch the rarely considered one. From this survey it is concluded that the mostly considered dimensions for finding context are physical, location, time, nearby objects and people. The moderate considered dimensions are activity, user and computing context. The least considered dimensions for finding context are emotion, virtual, internal, peer, process and service context. So, we can say that this survey provides the base work for future research in the area of context aware wearables and context based computing with respect to wearables.

REFERENCES

[1] B. Schilit and M. Theimer, "Disseminating active map information to mobile hosts," Network, IEEE, vol. 8, no. 5, pp. 22 –32, sep/oct 1994.

[2] http://www.wareable.com/wearable-tech/a-brief-history-of-wearables http://www.visualcapitalist.com/the-history-of-wearable-technology/ Mann, S., "Wearable Computing: A First Step Toward Personal Imaging, Computer", 30 (2), (1997/1), http://www.wearcam.org/ieeecomputer/r2025.htm

[3] Nahum Gershon, Bill Kapralos, and Steve Mann, "Games, Entertainment, and Media for Life, Health, and Community", IEEE Consumer Electronics Magazine,July 2015.

[4] W. Barfield, K. Baird, "Future directions in virtual reality: augmented environments through wearable computers", VR '98 Seminar and Workshop on Virtual Reality, Kuala Lumpar, 24-25 April 1998.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

[5] W. Barfield, K. Baird, "Issues in the Design and Use of Wearable Computers", Springer Verlag London Ltd, Virtual Reality (1998) 3: 157-166

[6] Thad Starner, "*Wearable Computing and Contextual Awareness*". PhD thesis, Massechusetts Institute of Technology, June 1999.

[7] Thad Starner "THE CHALLENGES OF WEARABLE COMPUTING: PART 1", IEEE MICRO, July-August 2001.

[8] Thad Starner "THE CHALLENGES OF WEARABLE COMPUTING: PART 2", IEEE MICRO, July-August 2001.

[9] Christian Plessl, et al., "The case for reconfigurable hardware in wearable computing" Pers Ubiquit Comput (2003) 7: 299–308

[10] Urs Anliker, et al. "A Systematic Approach to the Design of Distributed Wearable Systems" IEEE TRANSACTIONS ON COMPUTERS, VOL. 53, NO. 8, AUGUST 2004

[11] Oliver Amft et l.,"Design of the QBIC wearable computing platform" Proceedings of the 15th IEEE International Conference on Application-Specific Systems, Architectures and Processors (ASAP'04)

[12] Anthony Savidis, Constantine Stephanidis "Distributed interface bits: dynamic dialogue composition from ambient computing resources", Pers Ubiquit Comput (2005) 9: 142–168

[13] Naoki MIURA et al., "Aware-Mail: an Event-driven Mail System for Wearable Computing Environments". Proceedings of the 24th International Conference on Distributed Computing Systems Workshops (ICDCSW'04), 2004, IEEE.

[14] Andreas Krause et al.,"Trading off Prediction Accuracy and Power Consumption for Context-Aware Wearable Computing", Proceedings of the 2005 Ninth IEEE International Symposium on Wearable Computers (ISWC'05), 2005 IEEE.

[15] James F et al.,"Uses of accelerometer data collected from a wearable system", Springer-Verlag London Limited 2006.

[16] Leah Buechley and Michael Eisenberg, "The LilyPad Arduino: Toward Wearable Engineering for Everyone", PERVASIVE computing, IEEE 2008.

[17] Grace Ngai, et al., "Deploying a Wearable Computing Platform for Computing Education", IEEE TRANSACTIONS ON LEARNING TECHNOLOGIES, VOL. 3, NO. 1, JANUARY-MARCH 2010.

[18] GRACE NGAI, et l., "Designing i*CATch: A Multipurpose, Education-Friendly Construction Kit for Physical and Wearable Computing", ACM Transactions on Computing Education, Vol. 13, No. 2, Article 7, June 2013

[19] Kent Lyons, Halley Profita, "The Multiple Dispositions of On-Body and Wearable Devices", PERVASIVE computing, October-December, 2014, IEEE.

[20] Longhan Xie and Mingjing Cai, "Human Motion: Sustainable Power for Wearable Electronics", PERVASIVE computing, IEEE,2014

[21] Leslie Mertz, "Convergence Revolution Comes to Wearables", IEEE PULSE, January/February, 2016.

[22] Paul M.A. Baker, Maribeth Gandy, and Clint Zeagler ,"Innovation and Wearable Computing A Proposed Collaborative Policy Design Framework", IEEE INTERNET COMPUTING, 2015.

[23] Reuben Kirkham, Chris Greenhalgh, "Social Access vs. Privacy in Wearable Computing: A Case Study of

Autism", PERVASIVE computing, IEEE, 2015.

[24] Orlando Arias , et al., "Privacy and Security in Internet of Things and Wearable Devices" IEEE TRANSACTIONS ON MULTI-SCALE COMPUTING SYSTEMS, VOL. 1, NO. 2, APRIL-JUNE 201.

[25] FIDEL PANIAGUA DIEZ, et al., "TOWARD SELF-AUTHENTICABLE WEARABLE DEVICES", IEEE Wireless Communications, February 2015.

[26] Brian M. Gaff, "Legal Issues with Wearable Technology", COMPUTER, IEEE, 2015.

[27] Haik Kalantarian, "Detection of Gestures Associated With Medication Adherence Using Smartwatch-Based Inertial Sensors", IEEE SENSORS JOURNAL, VOL. 16, NO. 4, FEBRUARY 15, 2016.

[28] MIN CHEN, et al., "AIWAC: AFFECTIVE INTERACTION THROUGH WEARABLE COMPUTING AND CLOUD TECHNOLOGY", IEEE Wireless Communications, February 201.

[29] ZIXUE CHENG, et al.,"Just-in-Time Code Offloading for Wearable Computing", IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTING, 2015.

[30] Wei, J. , "How Wearables Intersect with the Cloud and the Internet of Things : Considerations for the developers of wearables", Consumer Electronics Magazine, IEEE , 2014.

[31] Charlotte Hill, freelance journalist, "Wearables – the future of biometric technology?", September 2015.

[32] Smita Jhajharia,et al., "Wearable Computing and its Application" (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (4) , 2014, 5700-5704.

[33] Cliff Randell, "Wearable Computing: A Review", Department of Computer Science, University of Bristol, U.K. Available: https://pdfs.semanticscholar.org/9897/6020b1a1df6eb5bea6f222523c0bf4e2b2fb.pdf . (URL)

[34] Daniel Roggen, Daniel Gatica Perez, Masaaki Fukumoto, and Kristof van Laerhoven, "ISWC 2013— Wearables Are Here to Stay", PERVASIVE computing , IEEE, 2014

[35] Bill N. Schilit, Norman Adams, and Roy Want, "Context-Aware Computing Applications", IEEE Workshop on Mobile Computing Systems and Applications, 8-9 December 1994.

[36] Brown, P.J., Bovey, J.D. Chen, X. "Context-Aware Applications: From the Laboratory to the Marketplace". IEEE Personal Communications, (1997) 58-64

[37] A.K. Dey, "Context-Aware Computing: The CyberDesk Project". AAAI 1998 Spring Symposium on Intelligent Environments, Technical Report SS-98-02 (1998) 51-54

[38] Anind K. Dey and Gregory D. Abowd "Towards a Better Understanding of Context and Context-Awareness", 1st International Symposium on Handheld and Ubiquitous Computing, September 27-29, 1999, pp. 304-307.

[39] Guanling Chen and David Kotz "A Survey of Context-Aware Mobile Computing Research", Dartmouth Computer Science Technical Report TR2000-381.

[40] HANS W. GELLERSEN, ALBRECHT SCHMIDT and MICHAEL BEIGL "Multi-Sensor Context-Awareness in Mobile Devices and Smart Artifacts", Mobile Networks and Applications 7, 341–351, 2002

[41] Gregory D. Abowd and Elizabeth D. Mynatt, "The Human Experience", PERVASIVE computing, IEEE, 2002.

[42] Paul Prekop and Mark Burnett, "Activities, Context and Ubiquitous Computing", Computer Communications, Special Issue on Ubiquitous Computing, 2003.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

[43] Anind K. Dey and Gregory D. Abowd , "A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications", HUMAN-COMPUTER INTERACTION, 2001, Volume 16, pp. 97–166.

[44] Nagendra Bhargava Bharatula, Paul Lukowicz, Gerhard Troster "Functionality-power-packaging considerations in context aware wearable systems", Springer-Verlag London Limited 2006.

[45] Donghai Guan, Weiwei Yuan, Sungyoung Lee and Young-Koo Lee* "Context Selection and Reasoning in Ubiquitous Computing", International Conference on Intelligent Pervasive Computing,2007

[46] Haesung Lee, Joonhee Kwon, "Combining Context-Awareness with Wearable Computing for Emotion-based Contents Service", International Journal of Advanced Science and Technology2010.

[47] Jiehan Zhou, Ekaterina Gilman, Juha Palola, Jukka Riekki, Mika Ylianttila, Junzhao Sun "Context-aware pervasive service composition and its implementation", Springer-Verlag London Limited 2010

[48] Daqiang Zhang,Hongyu Huang•Chin-Feng Lai, Xuedong Liang,Qin Zou,Minyi Guo "Survey on context-awareness in ubiquitous media", Springer Science+Business Media, LLC 2011.