


Taxonomy on Ambient Computing: A Research Methodology Perspective

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ABSTRACT

The rise of Internet-of-Things, Cloud infrastructure, and intelligent home solutions has resulted in the growth of Ambient Computing over the past decade. This article is an attempt to cluster the multi-dimensional research in ambient computing into relevant nodes. The author proposes a taxonomy in ambient computing, creating a logical arrangement of such nodes. An algorithm based on the cosine similarity function for calculating the distance between two ‘author keywords’ has been used to spawn the inter-nodal relationships. The vocabulary for the research has been generated from IEEE Xplore taking into consideration the relevant journal publications. The taxonomy will guide researchers to the relevant published literature about a certain area of interest instead of exhaustive search into a plethora of published research in ambient computing. The taxonomy exhibits exponential growth of research in ambient computing over the last three years.

KEYWORDS

Ambient Computing, Ambient, Author Keywords, Cosine Similarity, IEEE Xplore, Journals, Research, Taxonomy

INTRODUCTION

‘Intelligence’ forms the backbone of the evolution of Internet-of-Things (IoT) into Ambient Computing. The term has been coined much earlier but has received substantial attention recently in the last decade among researchers and big technology brands. Ambient Computing is the use of computers and the internet without consciously using them. It is the use of intelligent agents whose operating process utilizes a combination of hardware, software, human-device interaction, user experience and machine learning. The dramatic growth of technology and the drastic devaluation of IoT components have aided the present focus on Ambient Computing. With the projected rise of intelligent devices outnumbering the human population 5:1 within a couple of years, it has become imperative for the global research community to propose, regulate and standardize devices that are shifting the focus from personal computing to Ambient Computing. Progress has already been made with the proposal of an algebraic language for describing the time-dependent behavior of Ambient Intelligent System agents (Boukharrou, Ilié, & Saidouni, 2017). E-commerce being a crucial player in the domain, agents pose a real challenge in terms of providing end-to-end service quality assurance (Gaoyong & Huiling, 2008). The major dimensions of Ambient Computing are Cloud Computing, Structured and Un-structured storage devices, and Big Data; all catalyzing the growth of IoT devices. Performance analysis (Mondal, Sanyal, Chattapadhyay, & Mondal, 2019) and consumer privacy (Shamsi & Khojaye, 2018) (Yamin & Sen, 2018) form a pivotal point in success of such systems.

Any specific field of research comprises of multiple inter-related fields/concepts. For example the research field of Ambient Computing itself comprises of multiple research areas such as Artificial

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Intelligence (Zaharakis & Komninos, 2012), Machine Learning (Eng, Douglas, & Verschure, 2005), Big Data (Bhatt, Dey, & Ashour, 2017) (Dey, Hassanien, Bhatt, Ashour, & Satapathy, 2018), Healthcare (Elhayatmy, Dey, & Ashour, 2018) (Dey & Ashour, Ambient Intelligence in Healthcare: A State-of-the-Art, 2017) etc. to name a few. It demands rigorous literature search for prospective researchers to grasp certain references related to their domain of interest. Since the web is exploding with similar researches in a certain domain, hence a researcher has to go through huge amount of literature survey before shortlisting a few for further reference. Moreover, existing researchers in a certain domain trying to sort out a typical problem faces similar issues. Ambiguity also lies in the fact regarding pre-requisite knowledge that needs to be gained before exploring a certain domain. Very few people have clarity regarding the knowledge required before studying a certain area of interest. These issues formed the founding stones for the research presented in this article. This article presents the taxonomy which provides the readers with a connected graphical structure containing certain nodes. These nodes are basically knowledge/research domains related to Ambient Computing. Taxonomy is a branch of science which is related with classification. This communication classifies the broad research of Ambient Computing into sub-domains for compartmental grasp of references. The connection between the nodes are in a child-parent fashion which itself reflects which parent node knowledge forms a pre-requisite for research on a certain child node. Therefore, the readers are provided with a flow of references in an orderly manner. This article also provides the cluster of references for a certain node. Hence, a researcher gets hold of only those references which are related to his/her area of interest. Also, this article provides clustering of similar keywords or terms which have the same meaning into a certain node. Hence, ambiguity between different texts having same meaning in context to area of interest is also resolved. The author believes that the proposed taxonomy will serve those who intend to begin research in Ambient Computing, but also to those researchers who are presently pursuing research in some domain of Ambient Computing. It will also eliminate confusion between certain ambiguous keywords. This article also reflects the growth of research in Ambient Computing over the years clearly stating whether this domain is in demand or getting diluted.

This collective set of research areas are termed as the research landscape of Ambient Computing. Hence published literature in Ambient Computing comprises of research articles for all the inter-related fields. Such huge literature creates an obscurity and loss of focus in conducting relevant literature survey in a certain thrust area within a research landscape. The work in this article primarily addresses this issue by providing the taxonomy; thereby clustering the relevant literature according to thrust areas. Hence, the taxonomy will help researchers study a subset of published literature. The taxonomy also helps in judging whether a certain area of research is in focus/growth or losing interest. It also helps in shortlisting those articles which serve as a pre-requisite for conducting a research in certain areas. The author has used an algorithm (Sengupta & Sultana, Taxonomy of Decimal Multiplier Research, 2018) based on Cosine Similarity function (Equation 1) to design the taxonomy. IEEE Xplore has been used to generate the vocabulary using “Ambient Computing” as the seed term. The Automated Taxonomy Generation Process (Camina, 2010) has been used to create the taxonomy following the bibliometric method. The algorithm has been described in the subsequent sections. The complete explanation and use of Equation 1 will be discussed later in the article.

$$\text{Cosine similarity} = \frac{n_{x,y}}{\sqrt{n_x} \sqrt{n_y}} \quad (1)$$

Where $n_{x,y}$ = Number of articles containing both term ‘x’ and term ‘y’,

n_x = Number of articles containing only term ‘x’, and

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