Affective Computing from Digital Health: A literature review

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Abstract

Digital Health has become one of the area's most important from SARS-CoV2. Therefore, Covid-19 pandemic has accelerated the rise of new apps centered on digital health, which can help in healthcare. A review literature is conducted, whose objective is to show what are the research advances in the field of affective computing in the context of Digital Health. In addition, a set of questions are formulated to understand the concepts and how it could be related. Therefore, Clarivate Analytics' Web of Science, Scopus and PubMed databases were used in this search.

Keywords

Affective Computing, Medical Informatics, Digital Health, e-health, e-Healthcare, User Experience and Affective medicine.

1. Introduction

Who has not had a failure with a computer system or with our computer where we get a message with unintelligible codes where a button appears with the only option: "OK" and the program closes? or worse, the program closes without giving any explanation. Certainly, it would have been much friendlier if, when the catastrophic failure occurred, he had sent me a message with empathic characteristics and tried to reassure us, so as to achieve a much more natural interaction. What if this happens in the health field, e.g., with a patient?

In the health field we find users who are in a particular condition, they have health problems, and in many cases, they are also worried about how much the treatment or the examination that the doctor has prescribed will cost. They are tired, they feel bad, and these problems not only affect the patient himself, but often also his environment.

Affective Computing (AC) is related to arises from or intentionally influences emotion. Therefore, it explores how technology can inform an understanding of emotion, how interactions between people and technologies can be impacted by affect, and how sensing and affective strategies can transform human and computer interaction [1]. For example, by using physiological measures, such as face recognition, heart-rate variability and skin conductance, a computer can recognize key emotional states and related changes in the user. Therefore, emotions and health are highly connected.

Smith and Frawley [2] integrated emotions applied in medicine in two scenarios, such as (1) emotional user interfaces in virtual environments for healthcare for patients, and (2) emotions in computers as support for psychiatry. Picard integrated the term affective medicine, whose objective is to enable computers to recognize some of the most frequent emotions that people experience while

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interacting with technology [3]. Cohen showed that people in depression and with poor social interaction have high risks of suffering from a common cold [4]. Nowadays, applications of AC are included in areas such as mental health, health monitoring systems, personal wellness, diagnostics, among others.

Digital health is related with a variety of terms such as e-health, m-health and telehealth, which is related with applications of electronic patient records, remote monitoring, connected devices, rehabilitation, and more. Digital health includes information technology, big data, artificial intelligence to collect, share and analyze data of the patient to help healthcare professionals make informed decisions and to improve care.

In the literature review three main research questions. RQ1: What is the relationship between affective computing and digital health RQ2: What is Digital Health? RQ3: How could it be defined as Affective Health Digital?

2. Background

In this section we will describe a brief definition with affective computing and digital health.

2.1. Affective Computing

Affective Computing: computing that relates to, arises from, or influences emotions [2]. Emotions and feelings are part of our lives, helping in decision making, learning and communication. In recent times, researchers have attempted to provide machines with the ability to recognize, interpret and express emotions and feelings. Is a multidisciplinary field that ranges from computer science to psychology to social sciences to cognitive sciences. The objectives of affective computing can be divided into: (1) the initial objective is to design a computer system capable of recognizing and expressing emotions, and (2) the final objective is to continue with the design so that the computer can have emotions and use them in decision making [5].

Another way of defining affective computing is: "the set of techniques aimed at performing affect recognition from data, in different modalities and at different scales of granularity" [6]. Sentiment analysis, for example, performs coarse-grained affect recognition, as it is usually considered a binary classification task (positive vs. negative), while emotion recognition performs fine-grained affect recognition, as it aims to classify data according to a large set of emotion labels.

The work mainly addresses, among others, helping children with autism spectrum disorder to understand their emotions through facial expression [7] recognition and mobile technologies, pain detection from spontaneous facial expressions, emotional support through virtual agents [8], emotion-aware systems to promote human well-being, multimodal emotion recognition through deep neural networks, depression detection through vocal [9], facial and semantic communication signals, and automated mental state detection for mental health care [10]. Therefore, affective computing has a greater potential in the care and treatment of brain health disorders, which means that AC can recognize, interpret, process and simulate emotions [11].

Affective computing can be related with Human Computer Interaction (HCI) from emotions. HCI has studied emotions to evaluate interactions between user and computer. Wadley et al. [12] present a discussion with emotions from HCI, where authors present dimensions of emotion from HCI such as: Emotion may be either designed for, emotion is shaped, the mechanism of influence may vary, emotions may be desirable or undesirable, emotions may result from technology use immediately or may arise later, among others. Therefore, some studies are more focused on emotion recognition from facial expressions, sounds, body gesture and physiological signals. Those signals are used to evaluate the User eXperience [13] herefore, User eXperience can be defined as is defined by ISO 9241-210 a person’s

perceptions and response that result from the use or anticipated use of a product, system, or service [14] some studies refer as emotional experience [15].

2.2. Digital Health

According to WHO, Digital Health is the field of knowledge and practice associated with the development and use of digital technologies to improve health [16]. Digital health expands the concept of eHealth to include digital consumers, with a wider range of smart devices and connected equipment. It also encompasses other uses of digital technologies for health such as the Internet of things, artificial intelligence, big data and robotics.

Digital health is a broad, multidisciplinary concept where technology and medical care intersect. Digital health applies digital transformation to the field of healthcare, incorporating software, hardware and services. In this context, stakeholders in the field of digital health include patients, physicians, researchers, application developers, manufacturers and distributors of medical devices.

3. Method

In order to have an overview regarding the relationship between Affective Computing and Digital Health, a review of the scientific publications related to these keywords was carried out in this work. Although this is not a systematic review, to achieve this goal, the guidelines described in the flowchart presented in the PRISMA 2020 statement [17] were followed.

3.1. Keywords

In this preliminary search, we can see that when we search for "Affective Computing" adding another criterion to focus the search on the healthcare field with keywords such as "eHealthcare", "eHealth" the results decrease radically, which leads us to change the search approach. Table 1 shows keywords selected: "Affective Computing" (AC), "e-Healthcare (EHc)", "eHealth (eH)" and "Health (H)".

Table 1.
Comparison of scientific articles published in Scopus by key words.

Area/Year	2018	2019	2020	2021	2022	TOTAL
AC	403	485	508	545	78	2019
Ehc	101	137	126	183	46	957
eH	1.247	1.263	1.397	1.692	3.95	5.994
dH	443	753	1.249	1.972	951	5.368
AC & H	20	48	61	64	14	207
AC & eHc	-	1	1	1	-	3
AC & eH	2	-	-	1	1	4
AC & dH	-	1	2	1	1	5
AC & mH	1	4	5	-	-	10

In a second instance, a new search was conducted in the Scopus, Web of Science and National Library of Medicine (PubMed) databases using the following keywords: "Affective Computing", "Digital Health", "e-health", "health", "e*health", "Affective Medicine", "e-healthcare", "UX", "HCI", "User Experience", "Human Computer Interaction" and "Human-Computer Interaction".

STR_1 = (“Affective Computing” AND (“Digital Health” OR e-Health OR Health OR e*Health OR “Affective Medicine” OR “e-Healthcare”) AND (UX OR HCI OR “User Experience” OR “Human Computer Interaction” OR “Human-Computer Interaction”). Figure 1 shows publications by year found a total of 117 articles, 81 in Scopus, 25 in Web of Science and 11 in PubMed.

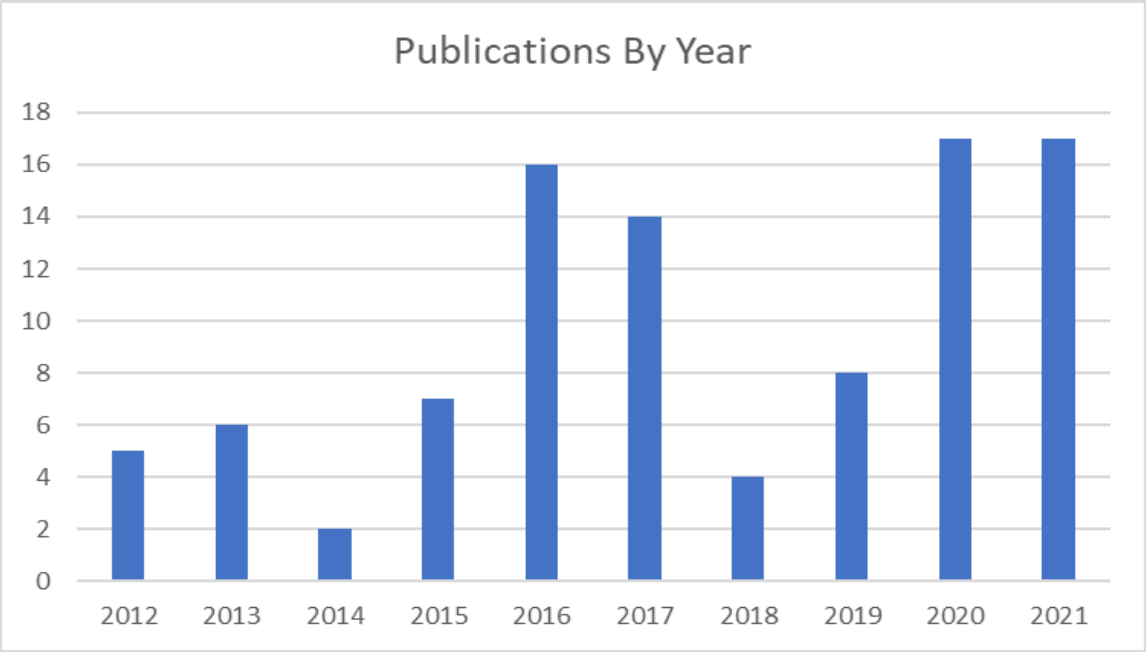

Figure 1: Total number of publications per year indexed in the three databases using the STR_1 search string.

Figure 1 shows the number of publications per year using the STR_1 search string, it would be of interest to know the reason for the low number of articles published in the years 2014, 2015 and 2018. Based on the results, a new search is designed in which the keyword "Health" is added, leaving the search string as follows: STR_2 = ("Affective Computing" AND ("Health" OR "mHealth" OR "m-Health" OR "e-Heatlh" OR "eHealth" OR "Digital Health")).

Table 2.
Comparison of scientific articles published in Scopus, Web of Science (WoSc) and Pubmed databases using the STR_2 search string.

Area/Año	<= 2017	2018	2019	2020	2021	2022	TOTAL
Scopus	146	21	49	62	63	14	355
WoSc	17	6	4	6	12	2	47
PubMed	34	11	12	15	22	5	99

Table 2 shows the results of the search without eliminating duplicate articles, where the total number of publications in Scopus and PubMed stand out, with 355 and 99 articles on this topic published to

date, respectively. On the other hand, eliminating duplicates, the total number of published scientific articles amounts to 402 papers. Figure 2 shows the upward trend of this research focus.

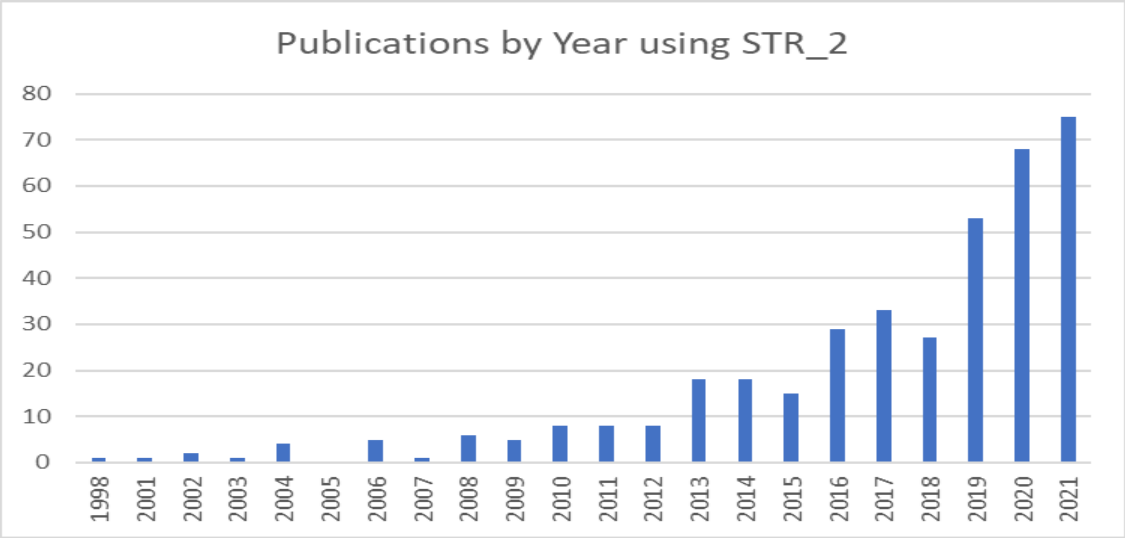

Figure 2: Total number of publications per year indexed in the three databases using the STR_2 search string.

Research in the field of Affective Computing has been relatively prolific in recent years, only in Scopus from 2018 to date we found 2,019 articles, even higher is the number of articles we found in the research areas of eHealth and Digital Health with 5,994 and 5.368 papers published from 2018 to date as shown in Table 1.

However, the number of articles decreases radically when we search by relating the concepts, thus when we search Affective Computing "AND" eHealth the total number of articles from 2018 to date is 4, similar is the case when we search by the keywords "Affective Computing" AND "eHealthcare" with only 3 results; on the other hand, when we narrow the search to show articles containing the keywords Affective Computing and Digital Health, the result is 5.

When we refine the search to the domains of Affective Computing, Digital Health, and User eXperience, using the STR search string, we find a total of 117 results: 81 articles in Scopus, 25 in Web of Science and 11 in National Library of Medicine (PubMed), the immediate next step is to discard repeated articles. When the keyword Health comes into play in the query chain, as proposed in STR_2, the scenario changes, we notice a growing focus of research, among the most recent works are topics such as autism spectrum disorder [18, 19, 20, 21], pain detection and recognition [22, 23], social and affective robots [24, 25, 26], agents [27, 28], remote health care [29, 30], among many other topics.

It is well known that there has been a growing interest in mental health, during the period of the COVID 19 pandemic, which is also reflected in the field of Affective Computing research. Figure 3 shows that as of 2020 of the 159 articles that consider Affective Computing and Digital Health, 45 are related to mental health, corresponding to 28.3%, this considering that publications prior to 2020 that are related to mental health within the topics described, are only 34 out of 242, which is equivalent to 14%.

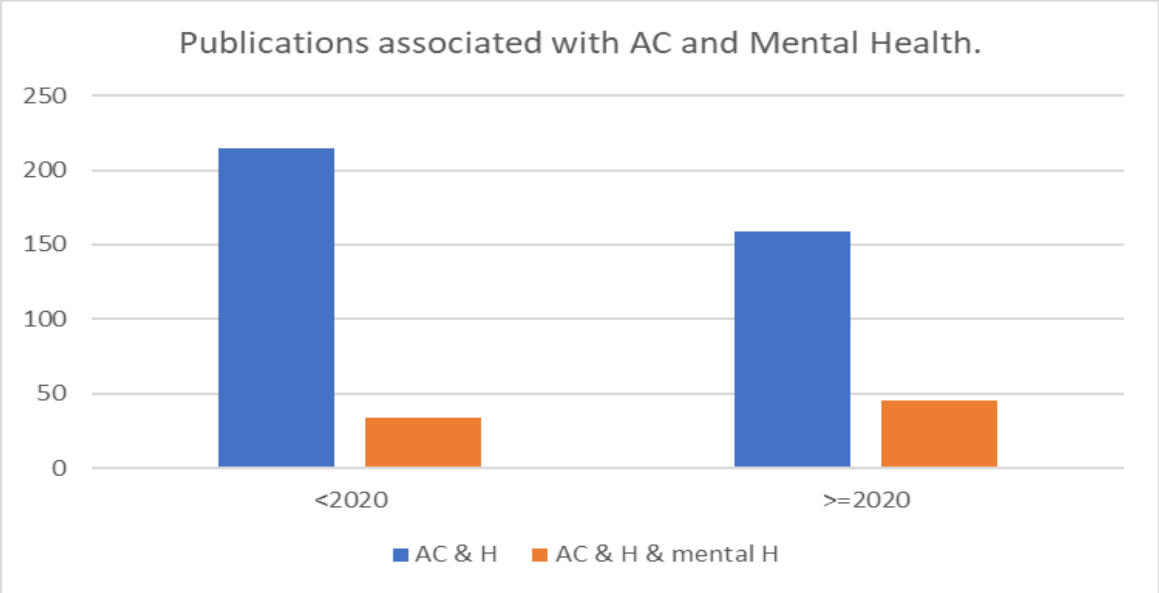

Figure 3: Publications associated with AC and Mental Health.

3.2. Inclusion and exclusion criteria's

Inclusion criteria:(1) Research that deals with experiences in the development of software for the health care field; (2) using Affective Computing techniques; (3) articles published within the last 10 years.

Exclusion criteria: (1) studies that refer to the use of wearables, other than "eye tracking", are excluded; (2) focus on hardware and electrical devices.

3.3. Research questions

RQ1. What is the relationship between Affective Computing and Digital Health?

According to what has been observed, there are only a few articles that relate digital health with affective computing, as shown in Table 1, however, the search shows a greater number of articles when searching with the entry: "health", in this sense we could extend the concept, based on the definition of health provided by the WHO, we obtain that the relationship between affective computing and health is becoming closer, making its way into digital health.

RQ2. What is Digital Health?

Digital Health is the concept that incorporates information and communication technologies (ICT) into healthcare products, services, and processes, as well as organizations or institutions that can improve the health and well-being of citizens. It can range from portable devices, sensors, mobile health applications, artificial intelligence, robotic caregivers, and even electronic records. According to the above, we can state that Digital Health is a concept that is composed of several dimensions, where the union of affective computing with health is one of those dimensions.

RQ3: How could it be defined as Affective Digital Health (ADH)?

There is no formal definition of ADH in the literature reviewed; this is a new concept that brings together the elements of health and digital health with the addition of those associated with artificial intelligence, to capture the emotions of patients and act accordingly. It is the union of a new force to digital health that can help us in the areas of mental health, wellness and remote care, detection and recognition of pain, measurement of stress, as well as sessions with empathic agents.

4. Conclusions

According to what has been observed, the number of published articles related to Affective Computing has been increasing steadily each year, the same occurs with areas such as Electronic Health Care, Electronic Health, Digital Health. Something similar occurs when searching for articles containing Affective Computing and Health, although the number of articles considering these two concepts at the same time, drops considerably.

Affective Computing focuses on emotions, on the essence of the human being, by reducing stress in patients we can make their interaction with systems a less unpleasant clinical experience.

There is no formal definition of affective digital health, however, this new concept brings together elements of digital health along with artificial intelligence to capture patients' emotions and act accordingly.

5. Future Work

The next step in this research work will be to conduct a systematic review of Affective Computing and Digital Health, for which the PRISMA 2020 methodology will be used.

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