Chatbots for the Detection of Covid-19: A Systematic Review of the Literature

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***Abstract*—At present, the development of chatbots is one of the key activities for the diagnosis of Covid-19. The aim is to understand how these chatbots operate in the health area to make a respective diagnosis. The purpose of the research is to determine the state of the art on the use of chatbots and its impact on Covid-19 diagnosis during the last 2 years. The data sources that have been consulted are IEEE Xplore, Taylor & Francis Online, ProQuest, World Wide Science, Science Direct, Microsoft Academic, Google Scholar, ACM Digital Library, Wiley Online Library, and ETHzurich. The search strategy identified 5701 papers, of which 101 papers were selected through 8 selection criteria and 7 quality assessments. This review presents discussions regarding the methodologies used for chatbot development, i.e., what are the purposes and impact of using chatbots for Covid-19 diagnosis. In addition, this is presents the results of how important the development and implementation of chatbots are in the area of health in the face of this pandemic.**

Keywords*—Covid-19 diagnosis; chatbot; NLP; digital assistants; health; systematic review

I. Introduction

The world is facing an unprecedented health crisis caused by the new coronavirus disease (Covid-19). Therefore, people are forced to go to health centers to rule out the disease, causing long queues. As a global pandemic, COVID-19 represents a problem in the care of patients in hospitals [107]. For this reason, many people initially turn to various sources on the Internet for self-diagnosis of their health before doing so with trained medical staff. The risk units of the Emergency Operations Center (EOC) attend online requests related to Covid-19 [108]. Direct telephone lines established by governments have collapsed due to the large volume of calls, generating long waiting times [109]. These health-related problematic situations are being solved with the help of Chatbots [110]. Thus, virtual agent applications are the latest inventions of the digital age. These applications are well known as conversational agents that run through programming or a type of artificial intelligence (AI) interaction between users and machines, with the intervention of natural language processing (NLP). Chatbots have been referred to as potentially the most promising and advanced form of human-machine interactions. It is therefore clear that chatbots play an important role in the process of Covid-19 diagnosis. These virtual agents (chatbots) are becoming involved in major global sectors such as health, banking, education, and agriculture. This paper focuses on the diagnosis of Covid-19 using chatbots. Likewise, the research is unique because a detailed review of the methodologies used for the development of chatbots has been carried out, what are the purposes and the impact of using these virtual agents, and 101 high-impact articles have also been rigorously reviewed. Also, because the research questions are original and have not been raised by any other researcher. The document is organized as follows. The present research is to close the gap concerning the lack of knowledge of the progress of research related to Covid-19 detection using chatbots. Section II describes the background this study and previous related research. Section III reviews the methodology applied. Section IV presents a systematic review of the results. Finally, Section V presents some concluding remarks and areas of future research.

II. Background and Related Studies

This section presents the background regarding the use of chatbots and discusses previous studies conducting systematic reviews of similar research.

A. Chatbots

A chatbot is a computer program through which it is possible to have a conversation, ask the user for information, or perform an action. This technology has helped to streamline processes in different areas, giving a faster response to users.

Several studies [1], [50] have emphasized the results provided by chatbots and have agreed on the rapid response they provide to users.

Based on previous studies, we identified the characteristics that chatbots provide, as well as their different areas of application, including their use in Covid-19 diagnosis and its impact. In this review, we thoroughly search and explore their application in the health field and more specifically, their role in the Covid-19 pandemic.

B. Previous Systematic Reviews

In recent months, reviews have been found on the use of AI for the diagnosis of Covid-19. A study was conducted on the use of AI for innovation in pandemic solutions [104]. Another study mapped the use of new technologies such as chatbots by health care organizations to improve mental health [103].

The authors investigated the use of various AI technologies for use in different solutions and the impacts they generate in times of pandemic. This shows the importance of AI in tackling the pandemic but does not mention much about the role of chatbots in diagnosing Covid-19. This review is then extended to the use of chatbots for the diagnosis of Covid-19 during this pandemic.

III. Methodology of Review

The review method used in this study was developed by considering the guidelines of B. Kitchenham [102] for conducting a systematic literature review (SLR). The review method elaborates the research questions, data sources, search procedure, exclusion criteria, quality assessment, data extraction, and data synthesis.

A. Research Problems

Table I shows the research objectives of this study through the correspondence between each research question and each motivation.

TABLE I. Research Objectives

Research Questions	Motivation
RQ1: What methodologies are used for the development of chatbots diagnosing Covid-19?	Identify the methodologies to be used for the development of a chatbot.
RQ2: In what areas are chatbots mostly being applied?	Identify the areas where chatbots are being used.
Q3: What are the purposes of using a chatbot for Covid-19 diagnosis?	Identify the purposes of using chatbots for diagnosing Covid-19.
Q4: What are the most important tools for developing a chatbot?	Identify the most important tools for developing a chatbot.
Q5: What are the most widely used programming languages in chatbot development?	Identify the most widely used programming languages in chatbot development.

B. Search Sources and Search Strategy

The source of the referenced data includes prominent digital libraries such as Taylor & Francis Online, ProQuest, World Wide Science, Science Direct, IEEE Xplore, Microsoft Academic, Google Scholar, ACM Digital Library, Wiley Online Library, and ETHzurich. The search strategy includes searches by keywords relevant to our study. The search has been focused on research questions and commonly used terms corresponding to machine learning and estimations of the software effort.

The search procedure has been carried out using search threads written as (chatbot) AND (covid or covid-19 or covid-19 diagnosis) where the set of Ai represents the keywords related to the automatic learning methods, i.e., Ai chatbot} and Bi represents the keywords related to the dependent variables, i.e., Bi {covid, covid-19, covid-19 diagnosis}. The results of the search procedure have been reduced to 5701 items that are discussed in more details below (see Table II).

C. Selection Criteria

Exclusion criteria have been defined to accurately assess the quality of the available literature. Papers have been reviewed and discussed by the authors for the exclusion decision with the industry advisor. The papers were checked against the given criteria:

EC1: The papers do not mention a methodology, model, or method.

EC2: The papers are not less than 2 years old.

EC3: The papers are not written in English.

EC4: They are scientific papers.

EC5: Titles and keywords are inappropriate.

EC6: The papers are not related to the topic.

EC7: It contains few citations.

EC8: The summary of papers is irrelevant.

The result of this stage shows 101 items.

D. Studio Selection

At the outset, 5701 results were obtained. When applying criteria 1 and 2, 2914 items were excluded. Likewise, when applying criteria 3 and 4, 1369 papers were excluded. Furthermore, when applying criteria 5 and 6, 565 papers were excluded. Finally, when applying criteria 7 and 8, 752 papers were excluded. This results in a total of 101 items (see Fig. 1).

TABLE II. Search Sources and Search Strategies

Source	Search equations
IEEE Xplore	((("Full Text & Metadata": chatbot) AND "Full Text & Metadata": covid-19 or covid-19 diagnosis) AND "Full Text & Metadata": method or methodology or model)
Taylor & Francis Online	[All: chatbot] AND [All: covid-19 OR covid-19 diagnosis] AND [All: method OR methodology OR model]
ProQuest	(chatbot) AND (covid-19 diagnosis OR covid-19 diagnosis) AND (model OR method OR methodology)
World Wide Science	chatbot and (covid-19 OR covid-19 diagnosis) and (model or Methodology or method)
Science Direct	chatbot and (covid-19 OR covid-19 diagnosis) AND (model OR method OR methodology)
Microsoft Academic	(chatbot) AND (covid-19 OR covid-19 diagnosis) AND (model OR method OR methodology)
Google Scholar	chatbot AND (covid-19 OR covid-19 diagnosis) AND (model OR method OR methodology)
ACM Digital Library	(chatbot) AND (covid-19 OR covid-19 diagnosis) AND (model OR method OR methodology)
Wiley Online Library	(chatbot) AND (covid-19 OR covid-19 diagnosis) AND (model OR method OR methodology)
ETHzurich	(chatbot) AND (covid-19 OR covid-19 diagnosis) AND (model OR method OR methodology)

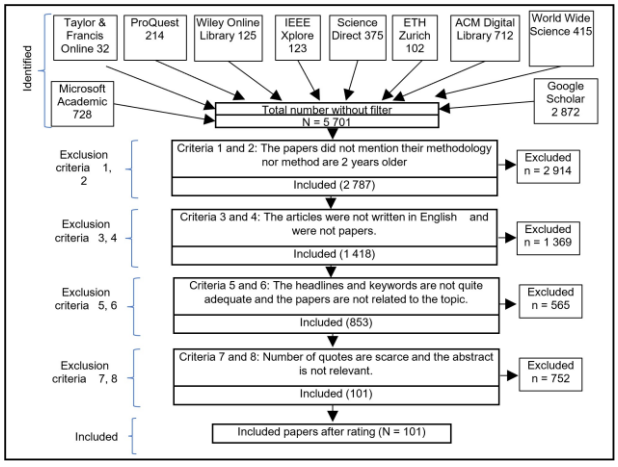

Fig. 1. Study Selection.

The figure shows how the exclusion criteria were applied and the result of this.

E. Quality Evaluation

Each of the 101 papers that remained after the selection criteria were evaluated independently using the following criteria.

QA1: Is the document well organized?

QA2: Does the topic belong to the fields of computer science, information systems, or management?

QA3: Are the objectives of the research clearly specified in the document?

QA4: Does the paper belong to a book, publication, or conference?

QA5: Are the results of the experiments performed clearly identified and reported?

QA6: Is the full text of the document available?

QA7: In general, is the document considered useful?

The result of this stage showed 101 papers, of which no papers were discarded because all met the quality criteria.

F. Data Extraction Strategy

During this stage, we extracted data from each of the 101 papers included in this systematic review according to 10 important data properties. The 10 properties considered in the extraction are Source, Year, Language, Research Areas, Type of Publication, Research Methodology, Authors, Number of Citations, Abstract, and Keywords.

Fig. 2 below shows the report of the studies collected in Mendeley to achieve a better control of the papers and facilitate the extraction of information.

G. Data Synthesis

The process of data synthesis includes gathering the data and finalizing the answers according to the research questions. The data synthesis has been achieved by analyzing the selected studies through multivariate regression techniques for a meta-analysis, as well as the following descriptive statistical measures: mean, mode, median, sum, count, and percentage. Tables, bar charts, frequency polygons, histograms, pie charts, sector diagrams, donut charts, scatter plots, georeferenced maps, and keyword clouds were also used.

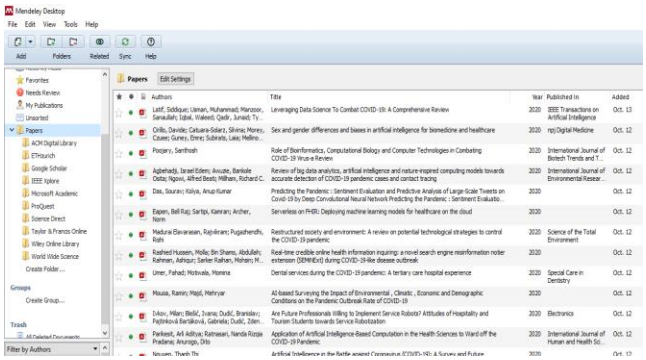

Fig. 2. Mendeley Paper Report.

IV. Result and Discussion

A. Overview of Studies

The study selection process conducted through the SLR resulted in 101 papers for data extraction and analysis from the most recognized sources, i.e., Google Scholar, ProQuest, Science Direct, Taylor & Francis Online, IEEE Xplore, and Microsoft Academic (Fig. 3). Fig. 4 shows the most recurrent words in the abstracts of the papers, through a word cloud and the number of repetitions of the most frequent terms.

It can be seen that the most frequently mentioned terms are Covid, health, pandemic, and digital. This means that, during the pandemic, the digital era has been of significant help in the area of health to combat Covid-19. With the use of machine learning, an analysis of publication results was executed, by country, institutions, keywords and citation counts [112].

In addition, Fig. 5 shows the number of papers per country of publication of this study.

It should be noted that the US is the country that has done the most research on Covid-19. The authors have reported that China has published 97 papers (42%) [111].

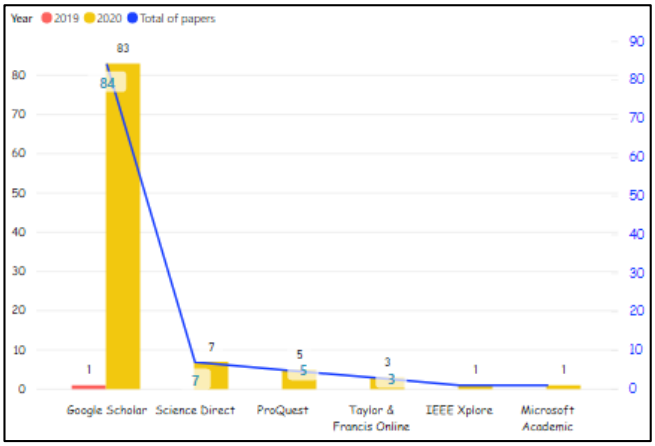

Fig. 3. Most Recognized Data Source.

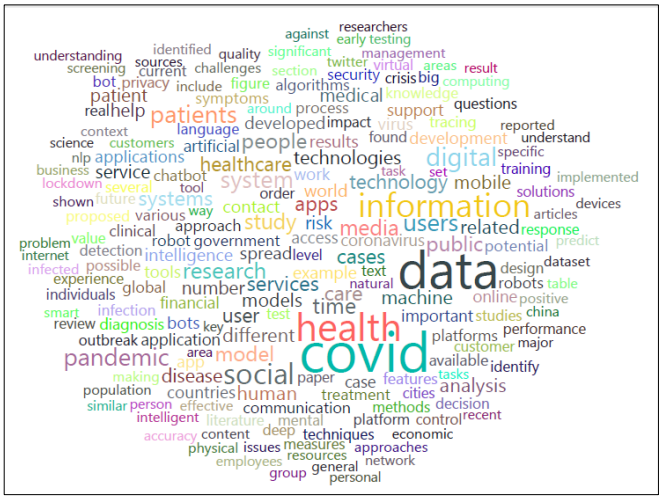

Fig. 4. Word Cloud in the Abstracts of Papers.

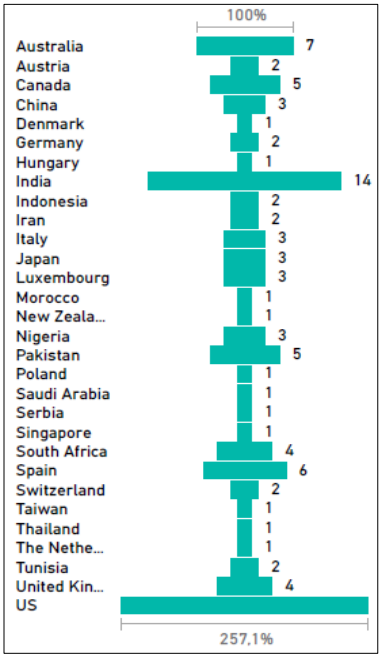

Fig. 5. Numbers of Papers by Country of Publication.

B. Answers to Research Questions

RQ1: What methodologies are being used for development?

The systematic review of the literature has resulted in 101 relevant papers. Each paper contains its own methodology for the development of chatbots used to diagnose Covid-19. We detected four different types of methodologies in the development of such chatbots. To provide a clearer view of our response, Table III was developed to answer the question more clearly.

The most widely used methodology for the development of chatbots is "sentence order prediction," which is used to predict the sentences a user may write and use the information to prepare a more effective response. The second methodology is "mask language modelling," which is used to predict the blank spaces in texts, which is necessary for the treatment of users. "Next sentence prediction" is being used because of the need to have a good user experience by speeding up the responses of the chatbots. The last methodology found is "learning based," which is a method based on continuous learning, where a chatbot learns based on constant conversations with the user.

TABLE III. METHODOLOGIES APPLIED FOR THE DEVELOPMENT OF CHATBOTS

Applied methodologies	Papers	Qty. (%)
Sentence Order Prediction	[2] [3] [7] [8] [3] [17] [21] [27] [39] [42] [48] [58] [65] [68] [71] [81] [86] [94] [99]	19 (34.5)
Mask Language Modelling	[1] [4] [8] [3] [6] [14] [20] [24] [45] [52] [62] [89] [90] [100]	14 (25.5)
Next Sentence Prediction	[13] [4] [8] [9] [14] [19] [24] [37] [45] [59] [68] [76] [91] [99]	14 (25.5)
Learning Based	[3] [7] [31] [61] [69] [76] [80] [89]	8 (14.5)

The use of different methodologies provides excellent results, and depending on the chatbots to be developed, several methodologies can even be implemented together [104].

RQ2: In what areas are chatbots being mostly applied?

A literature review demonstrated that there were five most important areas where chatbots have been applied. Table IV shows the areas where chatbots are being used.

TABLE IV. AREAS WHERE CHATBOTS ARE APPLIED

Application Areas	Papers	Qty. (%)
Health	[1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [17] [18[19] [20] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [35] [36] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [53] [54] [55] [56] [57] [58] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79] [81] [82] [83] [84] [85] [86] [87] [88] [90] [91] [92] [93] [94] [95] [96] [97] [98] [99] [100] [101]	93 (57.7)
Education	[1] [5] [7] [9] [12] [16] [19] [22] [26] [27] [30] [32] [34] [36] [37] [40] [42] [46] [51] [53] [54] [55] [57] [58] [77] [79] [81] [82] [84] [85] [89] [90] [98] [99]	34 (21.5)
Retail	[10] [12] [16] [33] [39] [43] [55] [60] [65] [59] [86] [89] [90] [97]	14 (8.8)
Banks	[12] [16] [27] [39] [55] [59] [72] [73] [80] [86] [90]	11 (8)
Tourism	[4] [22] [43] [59] [60] [65] [69] [77] [94]	9 (4)

One of the areas where chatbots are most applied is the health sector owing to its importance in human health and the impact it generates during the present pandemic. Another area where chatbots are applied is in the education sector where, through an agent that is able to respond to user needs 24 h a day, it is beneficial for different studies. In the banking and retail sectors, its application is increasing owing to the flexibility of chatbots to meet different business needs. Finally, in the tourism sector, the need to count on an agent that solves the frequent questions of the users and that is available at all times has led to the development of chatbots.

According to Alaa Ali Abd-Alrazaq [103], health is one of the areas where chatbots are most frequently applied, and the effectiveness and safety of chatbots in improving mental health has been measured.

RQ3 - What are the purposes of using chatbots for the diagnosis of covid-19?

As a result of a systematic review of the literature, we found three main purposes for using chatbots for the diagnosis of Covid-19. Table V shows the purposes of using chatbots for a Covid-19 diagnosis.

The most important purpose of using chatbots for Covid-19 is a high availability, in other words, to have a service that is always available to all users. User experience is one of the main reasons why we use chatbot for a Covid-19 diagnosis, which allows for a much faster, smoother, and better results. Agility is another extremely relevant reason because having a

space where one can obtain much more agile and personalized answers generates a positive impact for users.

According to Adam S. Miner [104], in line with our results in which we determined that a high availability is the main purpose for using a chatbot, the possibility to offer recommendations and diagnosis at any time has been observed.

Q4 - What are the most important tools for developing a chatbot?

When reviewing the relevant literature, it was observed that there are five important tools for the development of chatbots, which are the most widely used in the scientific field of AI. Table VI shows the most important tools for chatbot development.

The first and most widely used tool for developing a chatbot is DialogFlow, which is capable of understanding natural language and provides the infrastructure for creating conversations and building dialogue to interact with the user in a fluid manner. The second tool is Watson, which allows you to create, train, and implement conversational interactions in any application, device, or channel. Another tool used is Language Understanding, which is used for automatic learning that allows users to understand natural language and extract its meaning and understand what aspects are required. The latest tool found is AWS, in which previously trained AWS AI services provide ready-to-use intelligence in applications and workflows. AI services are easily integrated with applications to address common use cases, such as creating custom recommendations, upgrading a call center, improving security, and increasing customer involvement.

TABLE V. PURPOSES FOR USING A CHATBOT FOR COVID-19 DIAGNOSIS

Purpose of using chatbot	**Papers**	**Qty. (%)**
Availability|	[1] [2] [8] [9] [10] [12] [16] [22] [25] [26] [27] [37] [39] [42] [44] [46] [49] [51] [52] [53] [55] [57] [65] [69] [70] [72] [73] [74] [77] [81] [91] [92] [97] [98]	34 (68)
User experience	[2] [4] [28] [39] [43] [45] [55] [71] [97]	9 (18)
Agility	[40] [54] [65] [79] [84] [85] [89]	7 (14)

TABLE VI. MOST IMPORTANT TOOLS FOR CHATBOT DEVELOPMENT

Tools for chatbot development	**Papers**	**Qty. (%)**
Amazon Web Services (AWS)	[9] [24] [35] [36] [37] [43] [46] [67] [69] [73] [75]	11 (52.38)
Language Understanding	[8] [20] [21] [25] [51] [74]	6 (28.57)
Watson	[34] [98]	2 (9.52)
Dialog Flow	[51] [100]	2 (9.52)

According to Pavel Smutny [105], the most important tools for the development of chatbots are DialogFlow together with Watson and Language Understanding, which are capable of understanding natural language for establishing fluid dialogues with users.

Q5 - What are the most widely used languages in the development of a chatbot?

Through the results of the SLR, we found the four most widely used programming languages in the development of chatbots, as listed in Table VII.

TABLE VII. MOST WIDELY USED PROGRAMMING LANGUAGES IN CHATBOT DEVELOPMENT

Most widely used programming languages	**Papers**	**Qty. (%)**
Python	[5] [6] [7] [8] [15] [20] [23] [28] [29] [48] [52] [58] [71] [76] [95]	15 (68.18)
Java	[22] [28] [71] [77] [99]	5 (22.73)
JavaScript	[28] [71]	2 (9.09)
PHP		0 (0)

The most widely used programming language in the development of chatbots is Python because it is one of the preferred languages used on the server side to create a back-end; it also has many interesting features, among them, an interpreter and a high-level object-oriented programming language. The second most widely used programming language found in our research is JavaScript, which is ideal for handling high user traffic applications and events where hundreds of thousands of interactions are to be sent every second. Java is another programming language that is widely used to create applications and processes in a great number of devices and allows executing the same program in different operating systems. The last programming language is PHP, which is used to develop web applications, favoring the connection between the servers and the user interface. This programming language is widely used because it is open source, which means that anyone can make changes to its structure.

According to Eleni Adamopoulou [106], these programming languages are the most recognized in the development of chatbots because they are open source and effective for high user traffic applications. In addition, these languages support all functionalities and guarantee quick and easy access to information and application services for users.

V. CONCLUSION AND FUTURE RESEARCH

This study has managed to identify the impacts and purposes of Covid-19 diagnosis through chatbots, the areas where chatbots are most frequently applied, the methods used for their development, and the tools and languages needed for their implementation. The 101 papers reviewed for this analysis were chosen based on exclusion criteria and a quality evaluation. The results obtained indicate that the most widely used methodology for the development of chatbots is next

sentence prediction. The area where chatbots are mostly used is in retail owing to the high availability they offer to users. The most important purpose for using chatbots in the diagnosis of covid-19 is the agility of the response it provides to patients. The biggest impact generated is the satisfaction of the patients is by obtaining a fast response in their diagnoses. The most important tool for the development of a chatbot was found to be Watson Assistant owing to its easy integration with different communication channels. In addition, the most widely used language for the development of chatbots is Python owing to its easy integration and implementation. This review has certain limitations owing to the novelty of the topic; however, thanks to the motivation of the researchers regarding the topic because it is at a global level, a large number of papers were found to achieve a quality SLR.

The systematic review of the literature identified a new trend in the diagnosis of Covid-19, not only in the use of chatbot, but also on other technologies related to artificial intelligence, such as automatic and deep learning, which can contribute more efficiently to the diagnosis of Covid-19.

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