Medical Chatbot Techniques: A Review

Chapter · November 2020

DOI: 10.1007/978-3-030-63322-6_28

6 authors, including:

Edy Irwansyah
Binus University
56 PUBLICATIONS **265** CITATIONS

SEE PROFILE

Bayu Kanigoro
Binus University
30 PUBLICATIONS **189** CITATIONS

SEE PROFILE

Medical Chatbot Techniques: A Review

Andrew Reyner Wibowo Tjiptomongsoguno, Audrey Chen, Hubert Michael Sanyoto, Edy Irwansyah(✉), and Bayu Kanigoro

School of Computer Science, Bina Nusantara University, Jakarta, Indonesia
{eirwansyah,bkanigoro}@binus.edu

Abstract. In the current world situation, people are more concerned about their health. Unfortunately, nowadays the doctor human resource is lesser than the patient. These circumstances make a lot of people who seek treatment are unhandled. Many studies can solve this problem with some kind of chatbot or health assistant. In this paper, we want to explore and deepen more about chatbots that could help people to get the same and proper treatment as a doctor would do.

AQ1

Keywords: Chatbot · Health service

1 Introduction

In recent years, people get addicted to the internet in obtaining information for every problem they face. This not only yet people to seek knowledge about general topics but also their health concerns [15]. However, people are afraid of misinterpretation when they googled their symptoms since most search end up with creating unnecessary paranoid to the users and may sometimes inaccurate.

Based on that needs, people start to develop several technologies to help people get the most accurate results on their disease. One of them is by creating a yes-no answer questionnaire system. It certainly helps, however, due to some disease have almost the same symptoms as the other, we can't rely on this yes-no system since more information need to be elaborated to obtain accuracy. Another one is creating website whereas according to Aswini [3], a medical website plays a vital role in today's digital world and a lot of forum is available for answering the queries provided by the user.

The need for a reliable and accurate diagnosis wakes the rise of a new generation of healthcare technology called the Medical Chatbot. The main idea of creating this chatbot is to replicate a person's discussion [7]. This helps people to learn more about their symptoms and give them the most accurate diagnosis possible. The chatbot is also drawing upon the ever-growing medical question range, to broaden its already significant wealth of medical expertise. Many seemingly static scenes contain subtle changes that are invisible to the naked human eye. However, it is possible to pull out these small changes from videos through the use of algorithms via motion magnification [29]. Motion magnification gives a way to visualize these small changes by amplifying them and to pull out interesting signals from these videos, such as the human pulse [29]. Artificial intelligence (AI)

R. Silhavy et al. (Eds.): CoMeSySo 2020, AISC 1294, pp. 1–11, 2020.
https://doi.org/10.1007/978-3-030-63322-6_28

is an umbrella term for computer software consisting of a complex mathematical algorithm that processes input information to produce any specific pre-defined outputs, which lead to relevant outcomes [19]. AI systems, which utilize large datasets, can be designed to enhance decision-making and analytical processes while imitating human cognitive functions. AI has been applied in medicine and various healthcare services such as diagnostic imaging and genetic diagnosis, as well as a clinical laboratory, screening, and health communications [19].

2 Theoretical Background

For the technology, Bohle et al. [6] aims to create an "empathetic" embodied AI chatbot to search, retrieve, analyze, and communicate medical information and to interact with health care providers in natural language and "voice" using 3D facial expressions and gestures. There also a medical chatbot which used A Web-based text messaging application, Bonobot, was built as a research prototype to deliver the sequence in a conversation [20]. Kumar et al. [14] proposes a chat-bot with system: Input gathering and data pre-processing, medical terminology detection, mapping relevant document, and generating answers and solutions. Raj et al. [22] use NLP and NLU. NLP Text converted into structured data that is used to select a probable answer. There are several steps, Sentiment Analysis, Tokenization, Named Entity Recognition, Normalization, Dependency Parsing. NLTK library used to break sentences into words and reducing words to their stem. Multinomial Naïve Bayes used for text classification. This classifier treats every word independently later organized into two dictionaries, corpus_ words, class_ words. Each word is tokenized, stemmed, and lowercased and transformed into training data. Each class generates a total score for the number of words that match. Lots of information can be lost if given the wrong training data.

Dharwadkar [7] classifies the test image into the class with highest distance up to the neighboring point in the training. SVM training algorithm built a model that predict whether the test image fall into this class or another. SVM necessitate a vast training data to decide a decision boundary and computing cost is very high. The data which cannot be distinguished the input is mapped to high-dimensional attribute space where they can be separated by a hyper plane. SVM classifiers is faster to train. The accuracy of the SVM is greater than Naïve Bayes and KNN method which is near about 94% greater.

Other text processing proposed by [12] is *seq2seq* and *apriori* algorithm. The *seq2seq* model consists of two RNN, an encoder and a decoder. The encoder takes a sentence as input and processes one word one at a time. The decoder generates words one by one in each time step of the decoder's iteration. After one complete iteration, the output is generated. The *apriori* algorithm is used for finding frequent item sets in a dataset for Boolean association rules. The *apriori* principle can reduce the number of items sets we need to examine. The algorithm uses bottom up approach where frequent subsets are extended one at a time, known as candidate generation and group of candidates are tested against the data. It states that if an item set is infrequent, then all its supersets must also

be infrequent. This means that if pale eyes was found to be infrequent, we can expect pale eyes, cold to be equally or even more infrequent, so in consolidation the list of popular item sets, we need not consider pale eyes, cold, nor any other item set configuration that contains pale eyes.

CARO [9] uses Facebook AI Empathetic Dialogue dataset and Medical Question Answering dataset. The Empathetic Response Generator consists of four parallel LSTM followed by Concatenation and Dense layers. It considers the previous two utterances along with the current user input to maintain the context of the conversation. The model determines the emotion of the current user-text and prepends that to the text before passing it to the model. For both the generators, we have used teacher forcing as a method of training. In this method, the output at each time instance is generated based on what the model has generated in the previous time steps where the sentence started. However, LSTM cannot detect the keywords from a sentence [5].

Bao [5] proposed HHH using knowledge graph and Hierarchical Bi-Directional Attention. The knowledge graph is developed by Neo4j with data from the Health Navigator New Zealand, common illnesses and symptom and common diseases and conditions. When a user's question is given as input, it can be processed by two QA retrieval modules. (1) The information from "Web Interface Interaction" will be transferred into the information retrieval module. If the answer can be extracted directly from the knowledge graph dataset, the information retrieval module can retrieve and return the answer. (2) If, on the other hand, the required answer cannot be found from the knowledge graph. In this case, the question will be transferred into the question-answer pair retrieval module. HBAM will be used to check the semantic similarity of the user's question and the questions from the question-answer pair dataset. The top-k most similar questions will be returned as the answer set.

The last is Ensemble Learning [4]. Ensemble Learning depends on the presumption that diverse models trained autonomously are probably going to be useful for various reasons. Each model looks at marginally different parts of the data to make predictions, and getting some portion of reality however not every last bit of it. The popular methods of combining the classifiers in ensemble learning are mixture of experts, majority voting ensemble, boosting, bagging and stacking. Majority voting ensemble is actually a combiner method that can be used alongside stacking based ensemble learning. Stacking is based on a heterogeneous set of weak learners. Every classifier is trained autonomously, and final choice is made by a majority vote, averaging the result. Since the results are derived using ensemble learning of all classifiers and not a single classifier that could possibly dominate, it is a simple and efficient approach to combine weak and/or dominant classifiers while providing a good balanced output.

In this paper, we take 27 other paper as a foundation about the chatbot, especially our paper discusses medical chatbot techniques. The papers are shown in Table 1.

Table 1. Recent works of medical chatbot techniques.

No	Title	Methodology			Pros and Cons
		Method	Algorithm, Architecture, Model, etc.	Dataset	
1	A medical chatbot [7]	Support vector machine algorithm, NLP, Word Order similarity among sentences	Support vector machine, Natural language processing	Heart-disease dataset	Advantage: SVM can solve more complex classification and faster training. Disadvantage: NLP misinterpret
2	Diabot: a predictive medical chatbot using ensemble learning [4]	Ensemble learning	Classifier trained autonomously and final choice is made by a majority vote, stacking-based ensemble learning with majority voting ensemble as combiner	General health dataset and the Pima Indian diabetes dataset	Advantage: No Dominating classifiers. Disadvantage: Computation and design time are high
3	HHH: An online medical chatbot system based on knowledge graph and hierarchical bi-directional attention [5]	Knowledge graph and hierarchical bi-directional attention	Architecture: hybrid QA model framework, combines a knowledge graph to manage a medical dataset and HBAM to understand the text	3,500 entities (which include 675 diseases and 2825 symptoms) and 4,500 relationships. The relationship includes the relationship between the diseases, symptoms, and the other 6 properties	Advantage: Utilizes structured storage so that it may help easy maintenance and retrieval of domain-specific knowledge. While the advantage of the attention model utilizes deep learning to represent better and comprehend natural language questions. Disadvantage: Complex work
4	Chatbot for medical treatment using NLTK Lib [11]	NLTK	Breaking words, POS tagging, dot product to measure similarity	Wordnet, NLTK collection reader, a word database for English	Advantages: Easier to make. Disadvantages: There are some cases where the output hasvery low cosine similarity, and the answer may or may not be an exact match
5	Emergency patient care system using chatbot [22]	NLU, NLTP, Multinomial Naive Bayes	Sentiment Analysis, Tokenization, Named Entity Recognition, Normalization, Dependency Parsing	Corpus_words, class_words	Advantage: Simple to build. Disadvantage: No data provided for disease
6	A personalized medical assistant chatbot: MediBot [12]	RNN, NLP, Speech to text	Sequence-to-Sequence Model, Apriori	The model has been trained on the Cornell Movie Corpus dialogue dataset, se. The model is trained on dataset available from the New York Presbyterian Hospital	Advantage: The apriori principle can reduce the number of items sets we need to examine. Disadvantage: Lack of correct and accurate medical dataset, There is one more big challenge that the seq2seq model requires a lot of time for training even though the hardware is capable of handling it

(*continued*)

Table 1. (*continued*)

No	Title	Methodology			Pros and Cons
7	CARO: An empathetic health conversational chatbot for people with major depression [9]	Teacher forcing	A medical advice generator, and a general empathetic conversation generator with four parallel LSTM layers followed by Concatenation and Dense layers	Facebook AI Empathetic Dialogue [3] dataset and Medical Question Answering dataset [2]	Advantage: Accuracy of intent classifier was 98.5% and that of emotion classifer was 92.4% Disadvantage: Poor model performance and instability
8	What's up, doc? a medical diagnosis bot [1]	Text Mining with Wit.ai and use APIMedic	GloVe vectors, APIMedic	A survey of demographic information, a natural language description of symptoms, further elaboration on the symptoms, and the presumed diagnosis and ApiMedic database	Advantage: Complete dataset from API medic and easier to check symptom. Disadvantage: Not accurate result
9	Clinical medical knowledge extraction using crowdsourcing techniques [3]	MKE system	Truth discovery method, Trustworthy calculation	Guided interview,	Advantage: Variety of data. Disadvantage: Noisy dataset,
10	Automated medical chatbot [23]	Detect pattern using AIML	NLP and Classification	Medical QA Forum	Can capture long chat, provides solution directly
11	A conversational chatbot based on kowledge-graphs for factoid medical questions [16]	Kowledge-graph for factoid medical question	Natural language Intrepeter, Dialog Manager, Natural Language Generator	RDF Data	Efficient handle the dialog, ask missing information, generate more precise and contextualized response
12	"Plutchik": artificial intelligence chatbot for searching NCBI databases	Customized programming using AIML and LSL	Tensor Flow Algorithms and Data Visualization	NCBI suite of databases	Voice enabled
13	SHIHbot: a facebook chatbot for sexual health information on HIV/AIDS	Use NPCEditor to drive chatbot responses, a dialogue manager, and plugins to Facebook	Classification and NLP	Online Survey, QA in SHIHbot Domain	The live conversations will exhibit SHIHbot's ability to understand new questions, the chatbot's ability to cope with being asked questions outside of the domain knowledge, and the overall flow of dialogue
14	A survey on chatbot implementation in health care using NLTK [25]	Using NLTK	NLP	QA Record	User Friendly, Can be used by any person who knows how to type in their own language in mobile app or desktop version, Provides personalized diagnoses based on symptoms

(*continued*)

Table 1. (*continued*)

No	Title	Methodology			Pros and Cons
15	Conception and realization of a chatbotsystem to support psychological and medical procedures [28]	Conversation SDK, TaskQueue, ConversationCase	SVM, with some pre training by IBM. Entities use a fuzzy matching algorithm	Chat History	Only possible to implement the mobile application that is used to test the developed frameworks, This application allows the user to interact with it by asking questions about a specific topic, It represents the virtual assistant that can be used by patients and experts
16	Designing a chatbot for a brief motivational interview on stress management: qualitative case study [20]	Motivational interviewing	Braun and Clarke's thematic method	Survey of demographic information and perceived stress and a semistructured interview	The bot give encouragement
17	Quro: facilitating user symtom check using a personalised chatbot - oriented dialogue system [8]	Using UMLS	NLP and Data mining	Medical triage data	Provides a pre-assessment of probable conditions using learning algorithms across 7 million medical entities and patterns over a large-scale knowledge graph
18	Sanative chatbot for health seekers [13]	Input gathering and data pre-processing, Medical terminology detection, Mapping relevant document, Generating answers and solutions	Comparing the medical keywords in the query	Internet history search, Medical report	Relevant keyword Selection process, Handle large-scale data
19	Self- diagnosis medical chat-bot using artificial intelligence [24]	Implementing NLP to analyse human language	Natural language processing	Literature Survey	NLP can be wrong in answering questions
20	Chatbots meet eHealth: automatizing healthcare [2]	Case study	Using IBM Watson Conversation APIs by understanding natural language, Machine learning algorithm using Spark	Patient records from C.M.O center	Adaptable
21	Intelligent healthbot for transforming healthcare [10]	Study of existing system	NLP, Machine learning	HealtData site	

(*continued*)

Table 1. (*continued*)

No	Title	Methodology			Pros and Cons
22	Smart medical chatbot with integrated contactless vital sign monitor [29]	Database and automated diagnosis, Motion magnification, Proposed algorithm pipeline, Contactless vital sign monitor	Proposed algorithm	Clinical data set	High possibility to get accurate results.
23	Chatbot in mental health care [26]	Implementing NLP	NLP	Online survey	Flexible but not able to show human emotions.
24	Acceptability of artificial intelligence (AI)-led chatbot services in healthcare: a mixed-methods study [19]	Design, Data collection, Data analysis	AI hesitancy	Semi-structured interviews by online survey	Easy to analyze
25	Trust Me, I'm a Chatbot: How artificial intelligence in health care fails the turing test [21]	Data collection, Data analysis	Artificial neural network	Image scans	Easy to analyze
26	Trust in health chatbots [27]	Objectives, Data collection, Data analysis, System requirement	Neural Network	Medical dataset	Requires a lot of data
27	Mobile-based medical health application - MediChat App [17]	General objectives, Specific objectives, System requirement specification, Functional requirements, Non-functional requirements	Firebase for backend, Android for frontend	Survey on similar system	It's easy to get under everywhere because it's mobile

3 Methodology

This paper uses PRISMA checklist methodology [18] as the model of systematic review. We have chosen the PRISMA method because PRISMA is the recognized standard for reporting evidence in systematic reviews and meta-analyses. Figure 1 provides an overview of the number of journals, papers and articles that have been reviewed for the usage of writing this paper.

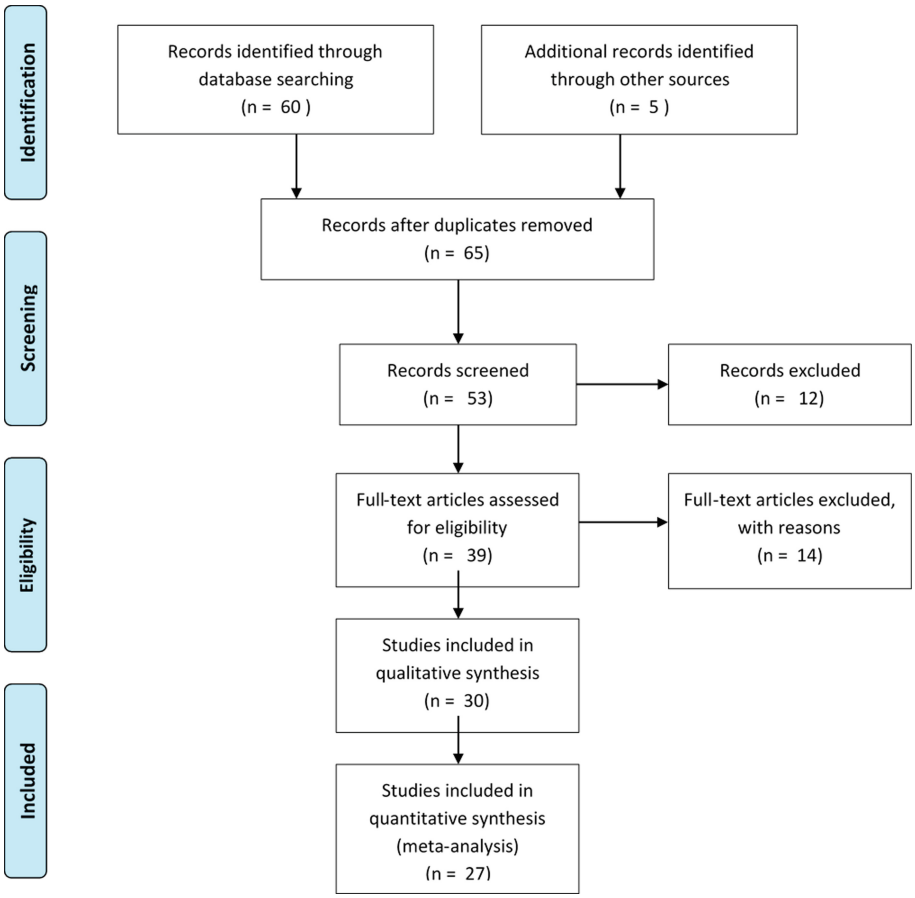

Fig. 1. PRISMA checklist methodology.

4 Result and Discussion

There several techniques used for a chatbot. The techniques that they use can we can classify as NLP, Machine Learning, Braun and Clarke's, Compare Keyword, and Data Mining. Ghosh et al. [8] have a research chatbot using data mining and natural language processing. NLP generation for user responses is based on predefined templates and system initiative to prompt easily interpretable responses from the user. Gajendra et al. [12] are also using NLP on his chatbot project. Based on his research we know that the goal of NLP is to take the unstructured output of the text input that is given as input to their chatbot system. Lastly, Raj et al. [22] also use NLP as on their chatbot system. Based on their research we can get the sentiment analysis of user experience with a chatbot. NLP also used to tokenize user input (string) to pieces or token so it can be processed by the system. Paper that uses machine learning is [4], which implements machine

learning and the key contributions of their work are ensemble learning. We learn that ensemble learning is going to be useful for various reasons such as each model looks at marginally different parts of the data to make predictions, getting some portion of reality however not every bit of it. Other papers, [7] also using machine learning with a support vector machine algorithm. From this paper, we learn SVM can distinguish two classes and discover the finest distinguishing hyperplane which minimizes the error for an unseen pattern. This constitutes for RQ1: What technique preferred for a chatbot?

The algorithm that matches medical chatbot is machine learning and natural language processing. There are some of the different algorithms used at machine learning such as ensemble learning, supervised and unsupervised learning, artificial neural network, binary regression, and classification. The NLP technique is for process the raw input from the user to a token that the machine learning can understand. Gajendra et al. [12] uses NLP to take the unstructured output of the Google API, which text input, is given as input to their chatbot system. After the text input is processed, the chatbot will respond with a series of questions to understand the situation of the user better. So basically, they use NLP to extract the keyword from the user input so it can be processed by the machine learning. Bali et al. [4] used Ensemble Learning to predict user disease base on the user symptoms that are given in the user input in the format of the token or processed string. This constitutes for RQ2: What technique preferred for a medical chatbot?

5 Conclusion

For short our paper discussed all the studies that related to a chatbot, especially medical chatbot. We learn and research the paper about how to make a chatbot, what kind algorithm the chatbot uses, and how to get the data set to train the chatbot. We see that there is a lot of algorithms we can use to make a chatbot like natural language processing, machine learning, Braun and Clarke's algorithm, compare keyword, and data mining. From those algorithms, we have seen that the most match algorithm for a chatbot is natural language processing and machine learning.

The major papers use natural language processing techniques to process the user input, that usually formatted as a string, to a format that the program can process. The raw input (string) can't be processed by the program or the architecture. The string format usually processed with the NLP method becomes a tokenized format. The tokenize format can be processed easily for the program rather than the string format. After the user inputs are tokenized, it can be processed with machine learning such as classification to process the symptoms and match to the disease that available in the classification training. So the most suitable algorithm to make a chatbot from our point of view are NLP and Machine Learning.

References

1. Agrawal, M., Cheng, J., Tran, C.: What's up, doc? a medical diagnosis bot
2. Amato, F., Marrone, S., Moscato, V., Piantadosi, G., Picariello, A., Sansone, C.: Chatbots meet ehealth: Automatizing healthcare. In: Workshop on Artificial Intelligence with Application in Health, Bari, Ital, pp. 40–49 (2017)
3. Aswini, D.: Clinical medical knowledge extraction using crowdsourcing techniques. Int. Res. J. Eng. Technol. **6** (2019)
4. Bali, M., Mohanty, S., Chatterjee, S., Sarma, M., Puravankara, R.: Diabot: A predictive medical chatbot using ensemble learning
5. Bao, Q., Ni, L., Liu, J.: Hhh: an online medical chatbot system based on knowledge graph and hierarchical bi-directional attention. In: Proceedings of the Australasian Computer Science Week Multiconference, pp. 1–10 (2020)
6. Bohle, S.: "Plutchik" artificial intelligence chatbot for searching NCBI databases. J. Med. Libr. Assoc. JMLA **106**(4), 501 (2018)
7. Dharwadkar, R., Deshpande, N.A.: A medical chatbot. Int. J. Comput. Trends Technol. (IJCTT) **60**, 41–45 (2018)
8. Ghosh, S., Bhatia, S., Bhatia, A.: Quro: facilitating user symptom check using a personalised chatbot-oriented dialogue system. Stud. Health Technol. Inform. **252**, 51–56 (2018)
9. Harilal, N., Shah, R., Sharma, S., Bhutani, V.: CARO: an empathetic health conversational chatbot for people with major depression. In: Proceedings of the 7th ACM IKDD CoDS and 25th COMAD, pp. 349–350 (2020)
10. Kadu, O., Sihasane, S., Naik, S., Katariya, V., Gutte, V.S.: Intelligent healthbot for transforming healthcare. Int. J. Trend Sci. Res. Dev. (IJTSRD) **3**(3), 1576–1579 (2019)
11. Kalla, D., Samiuddin, V.: Chatbot for medical treatment using NLTK Lib. IOSR J. Comput. Eng. **22** (2020)
12. KC, G.P., Ranjan, S., Ankit, T., Kumar, V.: A personalized medical assistant chatbot: Medibot. Int. J. Sci. Technol. Eng. **5**(7) (2019)
13. Keerthana, V.M.K.A., Madhumitha, M., Valliammai, S., Vinithasri, V.: Sanative chatbot for health seekers. Int. J. Eng. Comput. Sci. **5**(3) (2016)
14. Kumar, M.N., Chandar, P.L., Prasad, A.V., Sumangali, K.: Android based educational chatbot for visually impaired people. In: 2016 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), pp. 1–4. IEEE (2016)
15. Kumar, V.M., Keerthana, A., Madhumitha, M., Valliammai, S., Vinithasri, V.: Sanative chatbot for health seekers. Int. J. Eng. Comput. Sci. **5**(03), 16022–16025 (2016)
16. Minutolo, A., Esposito, M., De Pietro, G.: A conversational chatbot based on kowledge-graphs for factoid medical questions. In: SoMeT, pp. 139–152 (2017)
17. Mohammed, M.A., Bright, A.S., Ashigbe, F.D., Somuah, C.: Mobile-based medical health application-medichat app. Int. J. Sci. Technol. Res. **6** (2017)
18. Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L.A., et al.: Preferred reporting items for systematic review and meta-analysis protocols (prisma-p) 2015 statement. Syst. Rev. **4**(1), 1 (2015)
19. Nadarzynski, T., Miles, O., Cowie, A., Ridge, D.: Acceptability of artificial intelligence (ai)-led chatbot services in healthcare: A mixed-methods study. Digit. Health **5**, 2055207619871808 (2019)

20. Park, S., Choi, J., Lee, S., Oh, C., Kim, C., La, S., Lee, J., Suh, B.: Designing a chatbot for a brief motivational interview on stress management: qualitative case study. J. Med. Internet Res. **21**(4), e12231 (2019)
21. Powell, J.: Trust me, i'ma chatbot: How artificial intelligence in health care fails the turing test. J. Med. Internet Res. **21**(10), e16222 (2019)
22. Raj, P., Murali Krishna, R., Krishna, S.M., Vardhan, K.H., Rao, K.: Emergency patient care system using chatbot. Int. J. Technol. Res. Eng. **6** (2019)
23. Rarhi, K., Bhattacharya, A., Mishra, A., Mandal, K.: Automated medical chatbot. SSRN (2017)
24. Shifa, G., Sabreen, S., Bano, S.T., Fakih, A.H.: Self-diagnosis medical chat-bot using artificial intelligence. Easychair (2020)
25. Sophia, J.J., Kumar, D.A., Arutselvan, M., Ram, S.B.: A survey on chatbot implementation in health care using NLTK. Int. J. Comput. Sci. Mob. Comput. **9** (2020)
26. Vijayarani, M., Balamurugan, G., et al.: Chatbot in mental health care. Indian J. Psychiatr. Nurs. **16**(2), 126 (2019)
27. Wang, W., Siau, K.: Trust in health chatbots. Thirty ninth International Conference on Information Systems (2018)
28. Winkler, J.: Conception and Realization of a Chatbot-System to support Psychological and Medical Procedures. Ph.D. thesis, Ulm University (2019)
29. Zaki, W.M.A.W., Shakhih, M.F.M., Ramlee, M.H., Ab Wahab, A.: Smart medical chatbot with integrated contactless vital sign monitor. J. Phys. Conf. Ser. **1372**, 012025 (2019)