COMPREHENSIVE SURVEY OF RECOMMENDER SYSTEMS USING MACHINE LEARNING ALGORITHM FOR EARLY DETECTION OF CHRONIC DISEASES

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Abstract:
In last few years, there has been increase in volume of data being produced. Also, lately researchers have shown interest in how this data can be used for better decision making and monitoring of health parameters. Electronic Health Records (EHR) are rich in information and contain heterogeneous data from various sources. This data can be used to provide better healthcare to patient suffering from chronic diseases which, in most of the cases, are detected at a very late stage, and then it becomes fatal in most of the cases. If these diseases can be predicted by a recommender system at an early stage, based on the parameters of clinical data, the patient can take precautions and start medication at an early stage.
Machine learning forms the base of many information retrieval applications those effect our day to day lives directly or indirectly. Recommender systems are a classical example for machine learning applications, however, they have not yet been used extensively in health informatics and medical scenarios. In general, Recommender systems are information filtering system which takes users rating for items into account and predict user preferences. Many online ecommerce and other categorical websites are able to generate recommendations either on the basis of implicit feedback or explicit feedback. In implicit feedback, preferences are actually based on analysis of browsing patterns of the user, for example, purchase history, web logs etc. Explicit feedback is generated from the ratings provided by the user.
In this paper we are exploring the concept of Machine Learning, Recommender Systems, Types of Recommender Systems, Review of Recommender Systems, Issues and Opportunities.

Keywords: Machine Learning, Recommender Systems, Types of Recommender Systems, Review of Recommender Systems

I. INTRODUCTION

The Internet has become ubiquitous in the modern world. Used for shopping, watching movies, listening to music or communicating with friends. The activities of a huge number of people-Internet users-open up the possibility of gathering information from thousands, millions, and even billions of people. It is an invaluable opportunity for people who research this data. This allows them to define collective intelligence in the group under study-its behaviour, preferences, and world view. These are valuable insights, for example for the marketing market. They show whether their sales tactics for a given social group work, and sometimes help to come up with the best way to reach a given target group.

The Internet, in turn, allows you to monitor the various activities of network users without affecting their intentions. Data from various social groups around the world are at your fingertips. The biggest problem encountered by researchers and designers of systems based on data mining is the analysis of the information base. Due to its size, people are not able to effectively carry out complicated and tedious calculations on it. The problem of machine learning comes with help. One of the basic methods of machine learning can be statistical methods: regression and correlation analysis. More advanced methods are issues related to learning neural networks or fuzzy logic. The designer creates a recommendation algorithm, and the computer on its basis, acting on a given set of data, determines the conclusions related to the properties of this set. Such systems give great opportunities.

Recommendation systems are becoming more and more popular. Research on their subject has been somehow forced by the development of the Internet and its result-the flood of information. There are thousands of movies, millions of scientific articles, countless amount of music. These numbers mean that a single person is not able to get through all of this in his or her life. The recommendations are of inestimable value for such people.[1].

Machine Learning is the study of computer algorithms that improve automatically through experience. Applications range from data mining programs that discover general rules in large data sets, to information filtering systems that automatically learn

users' interests [19]. Various areas where machine learning can be applied are Image & Speech recognition, Medical Diagnosis, making predictions, extraction, classification, regression etc. Healthcare is one of the most important areas where its application can be seen.

With the ease of availability of technology and technological innovations, increased storage and computing facilities, it is possible to store and use the generated medical data for various research and analysis purposes. Various machine learning algorithms can be used to make predictions for the occurrence of chronic kidney disease in humans.

In this paper, different machine learning algorithms are revisited that can be used on a dataset containing information about patients' diagnosis for chronic kidney diseases. The paper is divided into few sections. Section II represents How CKD is identified?, Section II discusses various machine learning techniques, Section III discusses the relevant works performed so far for prediction of CKD in context of machine learning. In the Section IV, we analyze the techniques used for prediction and their success rate. In Section V, conclusion and and future scope has been presented.

II. BACKGROUND

2.1 CDSS (Clinical Decision Support Systems)

Most of the clinical decision support systems are knowledge based systems that rely upon the coded rule-based expert systems that use expert knowledge (IF-THEN-ELSE) to take out inferences from the given data. These rules are provided by the expert in that domain, i.e. physicians or healthcare professionals, on the basis of their experience (Tacit Knowledge). Thus, the knowledge base is limited to the knowledge of an expert, however it is possible to have knowledge pool of many experts (though it too has certain disadvantages). Also, it also suffers from the problem of localization, as the expert may be expert on the diseases of a particular geographic area, and if the system is to be ported to some other geographical location, the system needs to be modified according to that area.

Use of data-driven approaches allow us to automatically extract knowledge from clinical data, facilitates recommendations, learning from the past data and revealing unknown pattern from the available data.

Due to complex, heterogeneous sparse and multi-dimensional clinical data, traditional machine learning (ML) techniques like Support Vector Method, Neural Network or Decision Tree may pose problems. Recommender Systems can help us to overcome these limitations of traditional techniques like expert systems and machine learning.

2.2 Recommender Systems

Recommender Systems are traditionally used to personalize product suggestions on the basis of user's browsing history. Most of the applications of recommender systems can be found in E-Commerce sites (shopping etc.), recommending audio and video (on the basis of users search history) etc.

This paper presents an overview of the field of recommender systems and describes the current generation of recommendation methods that are usually classified into the following three main categories: content-based, collaborative, and hybrid recommendation approaches and context aware, semantic based and cross domain based approaches of modern recommender systems.

Traditional Recommender Systems

1) Content Based Filtering
2) Collaborative Filtering
3) Hybrid Recommendation Approach

Modern Recommender Systems

1) Context Aware Approaches
2) Semantic Based Approaches
3) Cross Domain Based Approaches

2.3 Machine Learning

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. **Machine learning focuses on the development of computer programs** that can access data and use it learn for themselves [18].

Due to different scenarios of availability of training data, test data and evaluation of teaching methods, the following types of machine learning algorithms can be distinguished [2]:

1) Supervised learning
2) Unsupervised learning
3) Semi-Supervised Learning
4) Reinforcement Learning

Supervised learning, trains a model on known input and output data so that it can predict future outputs, and **unsupervised learning**, finds hidden patterns or intrinsic structures in input data.

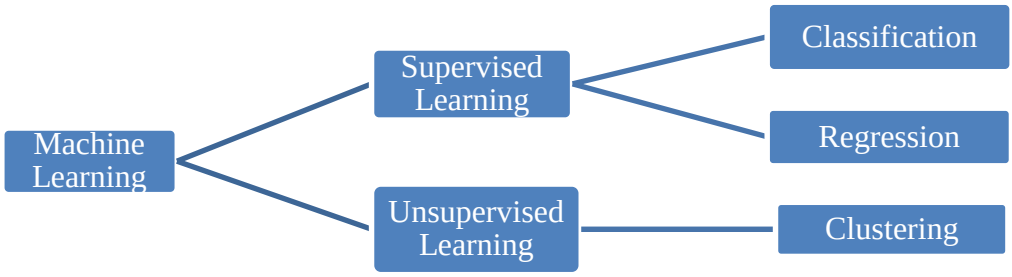

Figure 1: Machine Learning Algorithms

Supervised learning uses classification and regression techniques to develop predictive models. In this, In the case of learning with the teacher, the algorithm receives training data in which the output value known from the input data is known. This is one of the most popular learning methods.

- **Classification techniques** predict discrete responses—for example, whether an email is genuine or spam, or whether a tumor is cancerous or benign. Classification models classify input data into categories. Typical applications include medical imaging, speech recognition, and credit scoring. Common algorithms for performing classification include support vector machine (SVM), boosted and bagged decision trees, *k*-nearest neighbor, Naïve Bayes, discriminant analysis, logistic regression, and neural networks.

- **Regression techniques** predict continuous responses—for example, changes in temperature or fluctuations in power demand. Typical applications include electricity load forecasting and algorithmic trading. Common regression algorithms include linear model, nonlinear model, regularization, stepwise regression, boosted and bagged decision trees, neural networks, and adaptive neuro-fuzzy learning.

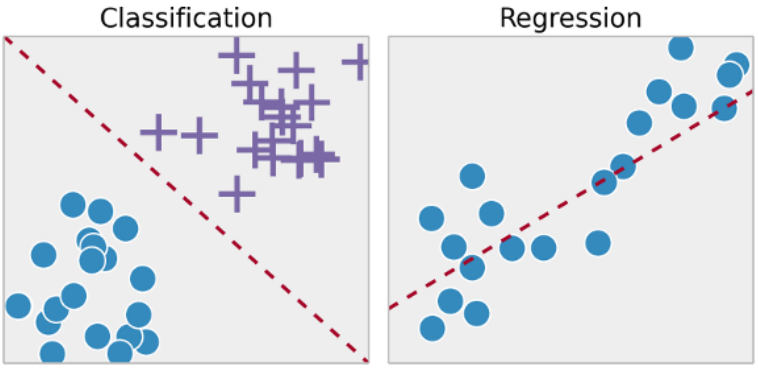

Figure 2: Supervised Learning Techniques [20]

Unsupervised Learning finds hidden patterns or intrinsic structures in data. It is used to draw inferences from datasets consisting of input data without labeled responses. In contrast to the teaching method with the teacher, the algorithm receives training data that does not take into account which output value should be obtained from the input data. In this scenario, the assessment of the extent to which the algorithm has mastered the training data can be troublesome.

- **Clustering** is the most common unsupervised learning technique. It is used for exploratory data analysis to find hidden patterns or groupings in data. Applications for cluster analysis include gene sequence analysis, market research, and object recognition. Common algorithms for performing clustering include k-means and k-medoids, hierarchical clustering, Gaussian mixture models, hidden Markov models, self-organizing maps, fuzzy c-means clustering, and subtractive clustering.

Figure 3: Clustering in Machine Learning

- **Dimensionality Reduction**

In this algorithm, original representation of the examined object is transformed into a representation of smaller dimensions without losing the original data. Since, over a period of time, the volume of data becomes too large for efficient interpretation. Thus, they can be reduced to single variable by discovering the correlation between several variables.

Semi-supervised learning Training data, while partially supervised, consist of samples having the expected initial value as well as samples that do not have it. This method is popular when the input data is easy to obtain, but the output data is much more expensive.

Reinforcement learning, in this training and testing phases are combined in a reinforcement approach. The learned algorithm collects data by interacting with the environment. The algorithm receives a reward or penalty, depending on the action taken. The purpose of this method is to maximize the reward for the learned algorithm.

III. LITERATURE REVIEW METHODOLOGY

Healthcare (HRS) is an emerging field of research, thus the literature search on all the databases demonstrates that new studies were mostly presented in conferences, rather than in the top scientific journals. Many papers on the field can be found on journals of conference proceedings. Thus, in this study, the literatures review consists of publications in conference proceedings.

The research method was built upon a review protocol in order to review the literature systematically. In the study, Kithchenam's systematic review procedure was employed. The following steps were pursued:

1. Determining the topic of the research
2. Extraction of the studies from literature considering exclusion and inclusion criteria
3. Evaluation of the quality of the studies
4. Analysis of the data
5. Report of the results

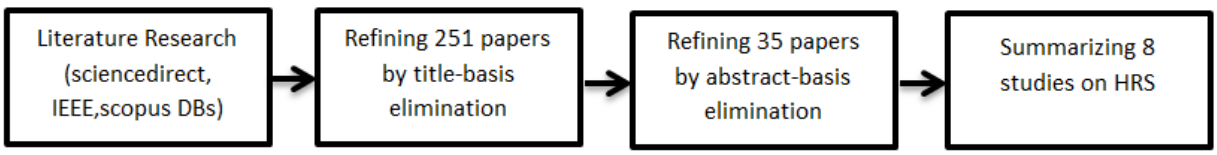

Figure 4. Literature Review process

Literature review started with research of leading academic databases (IEEE, ACM, Science Direct and Scopus). The keywords were composed of "health", "recommendation", "system", "recommender", "issues", "machine learning". Papers from last 10 years were considered for study. Then, the papers were shortlisted on the basis of title and abstract. Total of, 50 papers were retrieved, of which 18 papers were found meeting the criteria of quality: reliability of the source, integrity in the content and providing applicable studies. Finally, the findings were synthesized and reported from 11 papers that contributed most in the area of study.

There have been several limitations while conducting the study. First, the scarcity of academic resources in HRS was the main limitation. In addition to that, the studies were not explicitly providing details about their methods and techniques, and their variety of research approaches disallowed to make classification of HRS studies.

IV. FINDINGS AND DISCUSSION

In total, 11 papers were found likely to contribute to HRS review. Related work is discussed below:

1) In 2014, "Health Recommender Systems: Concepts, Requirements, Technical Basics and Challenges". This paper discusses about the use of huge amounts of data collected in clinical databases representing patients' health condition in the form of laboratory results, treatment plans & medical reports. Digital information available for patient-oriented decision making has increased drastically but is often scattered across different sites. Paper also points out the use of p*ersonal health record*

systems (PHRS) to centralize an individual's health data and to allow access for the owner as well as for authorized health professionals. Expert-oriented language, complex interrelations of medical facts and information overload pose major obstacle for patients to understand their own record and to draw adequate conclusions. R*ecommender systems* may help patient with laymen-friendly information helping to better comprehend their health status as represented by their record. They are referred to as *health recommender systems* (HRS). This paper gives an introduction to *health recommender systems* and explains why they are a useful enhancement to PHR solutions. In addition, we outline an evaluation approach for such a system, which is supported by medical experts. The construction of a test collection for case-related recommendations is described. Finally, challenges and open issues are discussed.

2) In 2016, André Calero Valdez, Martina Ziefle et al, "Recommender Systems for Health Informatics: State-of-the-Art and Future Perspectives", November 2016, The author has discussed about state of the art and future prospective of healthcare informatics in their Lecture Notes in Computer Science

3) *In 2016, Therapy Decision Support Based on Recommender System Methods, Felix Gräßer, Stefanie Beckert et al.. The author presents a system for data-driven therapy decision support based on techniques from the field of recommender systems. Collaborative Recommender and Demographic-based Recommender are proposed for therapy recommendation. Both algorithms aim to predict the individual response to different therapy options using diverse patient data and recommend the therapy which is assumed to provide the best outcome for a specific patient and time, that is, consultation. The methods are evaluated using a clinical database incorporating patients suffering from the autoimmune skin disease psoriasis. The Collaborative Recommender generates better predictions and recommendation quality. However, due to small sample size of data, this approach cannot be checked for recommendations for the entire database. However, the Demographic-based Recommender performs worse on average but covers more consultations. Both methods, if combined into an overall recommender system can yield better results.*

4) In 2016, Zheyun Zhong , Yinsheng Li "A Recommender System for Healthcare Based on Human-Centric Modeling", found that the existing recommenders in healthcare field didn't consider every dimension of user model and grasp the objective intent of the user accurately. Thus, they cannot effectively solve the problem of personalized healthcare recommendation. The authors propose HCB-CF a recommender based on human-centric model. HCB-CF excavates the latent relationships between the users and the semantic characteristics of item by matrix decomposition. And it also constructs user-user matrix to reduce the impact of the users' Sparse shopping data. The experimental results show that the HCB-CF approaches, compared with IBCF and UBCF, have obvious advantages in terms of precision, F1-Measure and sort priority. Therefore, the HCB-CF approaches can recommend the items that are in line with the users' objective intent. Due to the limited knowledge of healthcare profession, could not introduce users' latent characteristics into the semantic database, but the same can be done in future work.

5) In 2016, Youjun Bao, Xiaohong Jiang, "An intelligent medicine recommender system framework". Data mining and recommender technologies provide possibilities to explore potential knowledge from diagnosis history records and help doctors to prescribe medication correctly to decrease medication error effectively. In this paper, we design and implement a universal medicine recommender system framework that applies data mining technologies to the recommendation system. The medicine recommender system consists of database system module, data preparation module, recommendation model module, model evaluation, and data visualization module. We investigate the medicine recommendation algorithms of the SVM (Support Vector Machine), BP neural network algorithm and ID3 decision tree algorithm based on the diagnosis data. Experiments were done to tune the parameters for each algorithm to get better performance. Finally, in the given open dataset, SVM recommendation model was selected for the medicine recommendation module to obtain a good trade-off among model accuracy, model efficiency, and model scalability. We also propose a mistake-check mechanism to ensure the diagnosis accuracy and service quality. Experimental results show our system can give medication recommendation with an excellent efficiency, accuracy and scalability.

6) In 2017, Zheyun Zhong , Yinsheng Li "A Recommender System for Healthcare Based on Human-Centric Modeling", Aothur discusses the use of, Artificial Intelligence (AI) techniques like (a) fuzzy sets, (b) Artificial Neural Networks (ANNs), (c) Artificial Immune Systems (AIS) (d) Swarm Intelligence (SI), and (e) Evolutionary Computing (EC) are used to improve recommendation accuracy. Aim of the survey is to incorporate the recommender system in light of the AI techniques. Moreover, they tried to study the ability of AI techniques to deal with the above mentioned challenges while designing recommender systems. Furthermore, pros and cons of AI techniques were discussed in detail.

7) In 2018, Ishtiaq Ahmed ; Shiyong Lu , "Diagnosis Recommendation Using Machine Learning Scientific Workflows", In this paper, author presented a frequent itemsets and clustering based semi-supervised approach to recommending diagnosis labels with the help of labeled and unlabeled datasets. The overall recommendation workflow is implemented in DATAVIEW, one of the leading big data workflow systems in the community. This research work has several future research directions. Clustering methods are explored and evaluated for their impact of choosing a clustering method on the performance of the proposed model. Finally, the authors concluded, a multimodality dataset driven approach might be one promising direction to explore as medical data comes with other unstructured data such as medical images.

8) In 2018, Akshay Kamath, Amogh Parab, Neeraj Kerkar "Symptom Recommendation using Collaborative Filtering and Disease Prediction using Support Vector Machine" An efficient technique for disease prediction using support vector machines

was presented in this paper. The paper also provided an explanation of how collaborative filtering can be used to create a recommendation system for suggesting related symptoms. The system used Jaccard similarity measure for collaborative filtering. Various classification algorithms were compared using Precision-recall curve and accuracy on training and test set was calculated and support vector machines were then chosen. The statistical details for the same have also been presented. The proposed system performs disease prediction based on recent symptoms the person is suffering but doesn't take into consideration the duration for which the person is suffering these symptoms. Paper concluded that Effective results can be obtained if patients health profile generated overs years, is used for comparison and giving weights according to these durations.

9) In 2018, The Challenges and Opportunities for Healthcare Recommendation Systems in a Rapidly Evolving Health Data Ecosystem Keynote Mohammad M. Ghassemi. Existing Electronic Health Record (EHR) systems are rich, and often highly heterogeneous, sources of data. In the last ten years, there has been ample interest in how the growing volume of EHR data may be used to better monitor and support decisions at the bedside, with several of the largest industrial players now entering the arena (Google, Apple Microsoft and Amazon). But EHR systems are designed to mitigate clinical liability and facilitate billing, not to support algorithm development. As the most well-resourced data companies continue their push into healthcare domain, EMR systems will inevitably change to accommodate algorithm designers. In this talk, we will present several case studies that highlight the challenges and opportunities that are available in this rapidly evolving data ecosystem, and the import role that academic researchers can play in forging the future of recommendation systems in health.

10) In 2019, A Smart Recommender Based on Hybrid Learning Methods for PersonalWell-Being Services, Rayan M. Nouh, Hyun-Ho Lee, Abstract: The main focus of the paper is to propose a smart recommender system based on the methods of hybrid learning for personal well-being services, called a smart recommender system of hybrid learning (SRHL). The essential health factor is considered to be personal lifestyle, with the help of a critical examination of various disciplines. Integrating the recommender system effectively contributes to the prevention of disease, and it also leads to a reduction in treatment cost, which contributes to an improvement in the quality of life. At the same time, there exist various challenges within the recommender system, mainly cold start and scalability. To effectively address the inefficiencies, we propose combined hybrid methods in regard to machine learning. The primary aim of this learning method is to integrate the most effective and efficient learning algorithms to examine how combined hybrid filtering can help to improve the cold star problem efficiently in the provision of personalized well-being in regard to health food service. These methods include: switching among content-based and collaborative filtering; identifying the user context with the integration of dynamic filtering; and learning the profiles with the help of processing and screening of reflecting feedback loops. The experimental results were evaluated by using three absolute error measures, providing comparable results with other studies relative to machine learning domains.

The effects of using the hybrid learning method are gathered with the help of the experimental results. Our experiments also show that the hybrid method improves accuracy by 14.61% of the average error predicted in the recommender systems in comparison to the collaborative methods, which mainly focus on the computation of similar entities.

11) In 2019, Qiwei Han, Mengxin Ji, "A Hybrid Recommender System for Patient-Doctor Matchmaking in Primary Care", We partner with a leading European healthcare provider and design a mechanism to match patients with family doctors in primary care. We define the matchmaking process for several distinct use cases given different levels of available information about patients. Then, we adopt a hybrid recommender system to present each patient a list of family doctor recommendations. In particular, we model patient trust of family doctors using a large-scale dataset of consultation histories, while accounting for the temporal dynamics of their relationships. Our proposed approach shows higher predictive accuracy than both a heuristic baseline and a collaborative filtering approach, and the proposed trust measure further improves model performance.

V. CHALLENGES AND ISSUES

A. Cold Start/ Sparsity, in both these cases, it is difficult give recommendations to a new user having his browsing history empty or a user with very few elements in the search history, as the RS is based on browsing history. However, this may be solved by initial survey at the first attempt of use of such system so as to know user's preference.

B. Many a times, the browsing history may not speak the real voice of users. This raises issue of trust.

C. With the increase in the number of users of the system, the system may require more processing power for correct user recommendations. Thus scalability issues need to be handled with time.

D. Privacy Privacy has been the most important problem. In order to receive the most accurate and correct recommendation, the system must acquire the most amount of information possible about the user, including demographic data, and data about the location of a particular user. Naturally, the question of reliability, security and confidentiality of the given information arises. Many online shops offer effective protection of privacy of the users by utilizing specialized algorithms and programs.

VI. CONCLUSION & FUTURE WORK

The proposed system gives a fairly accurate prediction for a list of commonly occurring but serious diseases. For future work, one can rather focus on creating a single prediction model instead of a model for every disease. With the advent of health monitoring devices, one can produce a system providing an automatic and instant status of health report for an individual user without requiring user intervention or input to the system and also taking into consideration living conditions, habits and user history. Another feature which can be added to the system is the recommendation of doctors. Based on the symptoms entered by the patients the system will suggest specialists who are close to the patient's location area.

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