Frontiers in Artificial Intelligence and Applications

INTELLIGENT DECISION TECHNOLOGIES

Proceedings of the 5th KES International Conference on Intelligent Decision Technologies (KES-IDT 2013)

Edited by
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Frontiers in Artificial Intelligence and Applications

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Preface

The current volume includes the research results presented at the Fifth International Conference on Intelligent Decision Technologies (KES-IDT 2013) which took place in June 26-28, 2013, in Sesimbra, Portugal.

KES-IDT is a well established international annual conference, interdisciplinary conference in nature, and this edition consisted of keynote talks, oral and poster presentations, invited sessions and workshops, on the applications and theory of intelligent decision systems and related areas. It provided excellent opportunities for the presentation of interesting new research results and discussion about them, leading to knowledge transfer and generation of new ideas.

Sesimbra is a municipality lying at the foothills of the Serra da Arrábida, a mountain range between 40 km to the South of Portugal's capital, Lisbon. To the East of Sesimbra lies Arrábida Natural Park with natural caves, beaches and beautiful trails. To the West you'll find more beaches as well as Cabo Espichel with its scenic hiking trails, dinosaur footprints and ancient monastery. To the South lies Praia California and the Atlantic Ocean. Sesimbra is sheltered and the climate here is typically warmer than in most areas along the coast.

KES-IDT 2013 received many high quality submissions and all papers have been reviewed by at least two reviewers. Following a rigorous reviewing process, not all submissions could be accommodated for presentation at the conference. From these, 45 papers were accepted for presentation and included in this Proceedings. We are very satisfied with the quality of the program and would like to thank the authors for choosing KES-IDT as the forum for presentation of their work. Also, we gratefully acknowledge the hard work of KES-IDT international program committee members and of the additional reviewers for taking the time to review the submitted papers rigorously and select the best among them for presentation at the conference and inclusion in its proceedings.

We are also grateful to the KES personnel for their wonderful work in maintaining the KES-IDT 2013 website. Finally, we would like to thank the IOS Press personnel for their wonderful job in producing this volume.

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A Context-Sensitive Support System for Medical Diagnosis Discovery based on Symptom Matching

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Abstract. In this paper, we present a prototype of a clinical decision-support system. This prototype relies on a two-phase algorithm that is based on the differential diagnosis method from medical diagnostics and predictive models for disease occurrence in a subpopulation. The algorithm requires a data set containing information about diseases and their corresponding symptoms, and a data set with registered disease cases. The main output of this algorithm is a ranked list of diagnoses that might explain the manifested symptoms. The ranking is influenced by the patient's context, i.e., disease trends within a subpopulation to which the patient belongs. In the context of medical diagnosis discovery based on symptom matching, we present a short rationale for developing such a system, brief review of similar systems, algorithm for-diagnoses ranking, and ideas for future research. Furthermore, we elaborate on the required data sets and illustrate the application of the proposed solution with a typical use scenario.

Keywords. clinical decision support system, symptom checker, data mining, medical diagnosis, health informatics

Introduction

With the increased availability of databases containing vast knowledge regarding diseases and medical conditions, new possibilities arise for non-expert users who are interested in obtaining information about illnesses that they constantly face. However, the use of Web search as a diagnostic procedure, where queries describing symptoms are input and the resulting information, together with the associated rank, is interpreted as a diagnostic conclusion, may lead users to believe that common symptoms are likely the result of a serious illness. Such escalation from common symptoms to serious concerns may cause unnecessary anxiety, investment of time and expensive engagements with healthcare professionals [1]. Therefore, there is a strong need for trusted health and medical information about a set of manifested symptoms. Any software-based solution for such a requirement should also take into the account the fuzzy and incomplete nature of user queries and the lack of precise knowledge regarding symptom names in the general population. What complicates this issue even more is the fact that the relationship between symptoms and diseases is of the "many-

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to-many" type in which one symptom may be linked to many disorders and vice versa. In addition, the symptoms of disease may vary between individuals or disease subtypes.

Our goal is to create a pilot version of a software-based solution that could support, at least partially, one way symptoms-to-diseases matching while satisfying the aforementioned criteria. Moreover, as the Serbian healthcare system is undergoing extensive and significant modernization [2], this solution should primarily motivate stakeholders to more seriously regard IT solutions as an indispensable component in the modern provision of health services in Serbia. The proposed software system needs to support a scenario in which a user provides the list of present symptoms and relevant personal information, in order to obtain a list of potential diagnoses. What sets this solution apart from many other similar systems is its reliance on a broader patient context. This context sensitivity may be observed in the refinement of the initial ranked set of diagnoses that match a set of symptoms according to medical knowledge: the ranking of a matching diagnosis is increased if such diagnosis is often observed in the subpopulation to which a patient belongs and decreased if the diagnosis is rare (or not present) in the subpopulation In this manner, medical diagnosticians could utilize the system to more rapidly evaluate potential diagnoses in individual cases. Tasks that need to be carried out during the implementation of such system include: (i) collection of medical knowledge about diseases and their symptoms; (ii) collection of data that could help narrow down the search space of diseases by containing a valid excerpt of registered cases for different subpopulations; (iii) formulation of an algorithm that forms a list of possible diagnoses matching a list of symptoms by utilizing information from the two abovementioned data sets; and (iv) implementation of the algorithm and its integration into a software that is also designed for non-expert users.

This paper is divided into four sections besides the Introduction and Conclusion: Section 1, which gives an overview of similar solutions; Section 2, which presents data sets utilized in the proposed algorithm; Section 3, which describes the algorithm for symptoms-to-disease matching; and Section 4, which illustrates a use scenario for the algorithm in a software system for epidemiological research and monitoring.

1. Related Work

There are many clinical decision support systems (CDSSs) [3] and software systems that provide information on most common causes of provided symptoms. One group of such systems includes symptom checkers, online tools used to help educate users and suggest what condition certain symptoms could indicate. WebMD Symptom Checker [4] is one such example of a tool designed to help determine the underlying cause for a set of medical symptoms and learn about possible conditions. Different areas where discomfort or pain is being felt may be selected on the displayed human figure. Based on the selection, symptoms that are being experienced and related to that area may be further specified. Depending on the input, WebMD Symptom Checker provides information needed to determine the next steps in dealing with the symptoms, including recommendations to consult with a physician, as well as lifestyle changes. Another similar solution is the Isabel Symptom Checker [5], which takes a pattern of symptoms in everyday language and instantly computes the most likely diseases. When compared to our solution, both WebMD Symptom Checker and Isabel Symptom Checker ignore data about disease trends in a community to which the user belongs. Furthermore, they provide information only on the basis of symptoms being consistent

with a diagnosis. In this manner, those systems provide answers to such questions as: whether some symptoms might indicate a serious, perhaps chronic or fatal condition, or whether such fears are unfounded. Unlike our system, their results are not influenced by the results of an analysis that is performed over a set of registered disease cases.

The second group of such systems helps physicians to diagnose diseases. Internist [6] is one such example of a diagnostic program. It tries to explicitly capture the way human experts make their diagnoses, using a complex problem-solving strategy based on the technique of differential diagnosis that clinicians use every day. Its main strengths with respect to our solution are two parameters supplied for each finding (such as symptoms and test results), indicating the correlation between disease and finding. The first parameter represents the likelihood of the disease given that the finding occurs. The second parameter represents the likelihood of the finding given that the disease occurs. Values of both parameters for each association between disease and finding within Internist's knowledge base are a result of many man-years of effort provided by a team of physicians. On the other hand, our solution provides estimation of these parameters on the basis of number of symptoms consistent with a disease and number of diseases associated with a symptom. However, there is a conceptual difference between these two systems regarding algorithm and usage scope. Our solution is intended to be used outside the physician's office, as well. In this manner, it may be used by people other than healthcare professionals, in which case it has only informative purpose. Furthermore, it is a web-based system that may be used through a regular web browser and easily made public. As far as the algorithm is concerned, unlike Internist, our solution utilizes predictive models to refine the initial results that are based solely on observed symptoms. The user may also set how much the final score assigned to each diagnosis is going to be influenced by the results of the corresponding predictive model. The final score is dependent on the parameter that determines the ratio of scores provided by separate phases of algorithm, one of which relies on predictive models. DXplain [7] is a decision support system developed at the Laboratory of Computer Science at the Massachusetts General Hospital. It utilizes a set of clinical findings (signs, symptoms, and laboratory data) in order to produces a ranked list of diagnoses that might explain the clinical manifestation. Furthermore, it suggests what further clinical information would be useful to collect for each disease, and lists what clinical manifestations, if any, would be unusual or atypical for each of the specific diseases. However, similarly to our solution, it is not intended to be used as a substitute for professional medical advice. Another similarity is that it also offers a ranked list of diagnoses with corresponding sets of not observed symptoms. These symptoms are provided as guidance in making decisions about which laboratory test to order or which symptoms to observe. On the other hand, the principal difference lies in the ability to rank the diseases based on the epidemiological trend in the subpopulation.

The strong point of our solution when compared to the aforementioned solutions is the possibility to reduce errors caused by different probabilistic relationships between findings and diagnoses in different patient populations. The reduction is done by utilizing a data set with registered disease cases in a subpopulation. In this manner, among diseases with similar sets of symptoms, higher ranking is given to those more consistent with disease trends within the specified subpopulation. Therefore, the relationship between the symptoms and a disease to which the subpopulation is more susceptible has a greater significance. Our solution is a complex system that has traits typical of both symptom checkers and CDSSs: (i) it may provide information about the meaning of observed symptoms; and (ii) support medical diagnosis discovery.