Data-Driven System for Treatment of Obese Children in Rural Areas

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ABSTRACT

Child obesity is an increasingly pervasive problem. Traditional therapy programs are time- and cost-intensive and their success is often not guaranteed due to the individual characteristics of patients. Thus, a more patient-centric approach is necessary. Furthermore, rural populations in low-income areas often suffer from difficult access to healthcare. In this position paper, we introduce a data-driven system which uses low-cost devices for predicting performance and therapy success of obese children by applying machine learning methods. By using data-driven systems for e.g. predicting outcomes of a therapy, physicians could personalize standard therapies and improve the outcome bringing low-income areas within reach for quality healthcare. The envisioned data-driven system as an output from our mHealth project provides positive evidence as a tool for personalized mHealth systems among physicians.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer Interaction (HCI)**; • **Empirical studies in HCI**;

KEYWORDS

Data-driven systems, child obesity in rural areas, prediction of therapy success, machine learning, empirical studies, heart rate

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1 INTRODUCTION

The prevalence of obesity is markedly increasing in all populations and age groups worldwide [1]. Obesity is associated with numerous comorbidities including lifestyle diseases and the progression of coronary atherosclerosis, which are all risk factors for cardiovascular disease (CVD) [2-4]. Studies have shown that obese children tend to be obese as adults [5-7]. Moreover, persistence of child obesity increases with age [8-12]. Therefore, preventive measures in early age are crucial. However, therapy success is often not guaranteed due to patients' individual characteristics and failed therapies lead to frustration for both, obese children and their parents [13]. Thus, a more patient-centric approach is necessary placing individual patients at the center of therapies and analyses which treatments are optimal for each patient [14-16]. Furthermore, higher incomes in rural areas as a result of economic growth allow disproportionally more spending on food and hence higher caloric intake [17-20]. These changes, referred to as *urbanization of rural life* by some researchers [21], have contributed to a larger increase in rural BMI [22, 23]. Therefore, healthcare systems have to adjust the way they plan treatment, evaluate, and care for obese patients, especially in rural areas, using methods that do not rely on in-person services [24]. Combining existing methods with new and evolving mHealth technologies allows physicians to (a) provide new and efficient patient-centric healthcare and (b) reach out to patients in rural areas with difficult conditions. The increasing trend of mHealth technologies has the potential to revolutionize health disciplines such as child obesity. However, interdisciplinary design and evaluation frameworks are mostly neglected [25, 26]. Furthermore, the machine learning hype has fuelled a controversial discussion, and even human rejection, up to the point that physicians may feel threatened by machine learning overtaking their jobs in the near future [27]. Thus, interdisciplinary collaboration with physicians and evaluation of data-driven systems is necessary. This position paper presents data-driven system based on machine learning using unobtrusively and easily measurable vital signs in combination with static parameters for prediction on sport performance as well as therapy success. Furthermore, we present experiences with the underlying interdisciplinary mHealth project describing the empirical study on the adoption of the data-driven service amongst domain experts. Moreover, critical discussion points related to data-driven systems in the scope of child obesity are presented.

2 PREVIOUS WORK

Nurten Öksüz, Russa Biswas, Iaroslav Shcherbatyi, Wolfgang Maass. 2018. Measuring Biosignals of Overweight and Obese Children for Real-time Feedback and Predicting Performance. In Information Systems and Neuroscience, Springer, Cham.

The first paper focuses on measuring biosignals, more specifically heart rate of obese children during a 6-minute running test [28]. We investigated whether it is possible to predict the performance

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of obese children during the running test based on the static parameters BMI and gender as well as dynamic parameters, i.e. heart rate related data during the 6-min running test. This approach is a vital signs-based service, which uses low-cost devices making prediction on an individual's performance. The fittest study was conducted at a Swiss children's hospital in St. Gallen. Twenty children aged between 11 and 17 years (7 female and 13 male) with higher BMI values (25<BMI<37) participated in the fittest. The participants were equipped with a Scosche Rhythm+ heart rate monitor and a Samsung Galaxy S6 smartphone. The app called *PathMate2* collected the data to the server, where the data is processed for predictive analysis. The initial heart rate as well as the heart rate during the exercise was measured. Right after the exercise, the heart rate of the participants during the 3-min cool down was measured too. We intended to predict the number of laps during the 6-min running test using ML method. The features used to train the model were *BMI, gender, average heart rate* during the running *test* and *heart rate recovery*. The results show that the average difference between the actual number of laps and the number of laps predicted by our model is 2.185 with an overall average error of 7.1%, outperforming the baseline model. It can be concluded from our results that pre-exercise and post-exercise heart rate as well as BMI and gender can be leveraged to predict the performance of children during the running test. Therefore, low cost wearable devices along with predictive analysis methods allow predicting health conditions reducing the cost of the traditional therapy programs and help physicians to provide treatment to obese children and their parents in low-income areas having difficulties in gaining access to healthcare, such as rural areas.

Nurten Öksüz, Iaroslav Shcherbatyi, Tobias Kowatsch, Wolfgang Maass. 2018. A Data-analytical System to Predict Therapy Success for Obese Children. ICIS 2018 Proceedings.

In this paper, we presented a data-driven system, namely Data-analytical Information System (DAIS) providing predictions on therapy success, i.e. the future BMI changes before conducting the therapy as such [29]. The study design was similar to [28]. The introduced DAIS considers static parameters height, weight, BMI, age and additionally a variable which indicates whether a patient is currently undergoing therapy A or therapy B. Furthermore, heart rate related data during the 6-min running test has been used for the predictive analysis. The goal of the DAIS is to provide a decision support system for physicians to personalize standard therapies and improve the outcome. The DAIS is designed to collect sensory data using unobtrusive commodity hardware and additional static features from patients. The sensory data together with the static features are stored in a web - server where ML methods are used for predictions on whether BMI will decrease in the future. The analysis results by our DAIS are shown to health professionals via visualization with the help of a web app/graphical user interface (GUI). Based on the results, health professionals can make adjustments to the current therapy if necessary. We collected data from randomized clinical trial and trained ML models to estimate whether BMI will decrease after therapy. Various ML methods have been applied with linear support vector machine performing best (accuracy (acc.) = 85%). Moreover, the accuracy of linear support vector machine has been compared with domain experts' predictions on the BMI change over time. The results show that our ML model outperforms both experts (acc. domain expert 1 = 40%; acc. domain expert 2 = 60%).

3 EXPERIENCES WITH MHEALTH PROJECT

Both papers introduced are research findings from the cooperation with *University of St. Gallen*, *ETH Zurich*, the *University of Geneva* and the Swiss children's hospital *Ostschweizer Kinderspital*. Computer scientists, engineers and medical experts were collaborating in this interdisciplinary project in order to develop an information system which allows obese children and their physicians to stay in touch and communicate with respect to suitable therapies. With the help of PathMate2, it was intended to help physicians to analyze the data of their patients in real time, and provide them with information about suitable therapies tailored to their needs.

4 CRITICAL DISCUSSION POINTS

Pathmate2 as an interdisciplinary project created challenges as well as opportunities for all involved partners. One of the biggest challenges in the scope of Pathmate2 was the number of participants in the study as the data source for the machine learning models. The recruitment of obese children and few drop outs during the study posed problems to the team. Nevertheless, to create ML models with significant results, carefully chosen predictive analytics methods including intense preprocessing for small datasets have been used. Furthermore, satisfying the needs of physicians with respect to the envisioned DAIS and its applicability to medical field was challenging. To handle this challenge, intense discussion about the incremental design of the web-based system was necessary. Furthermore, to assess the domain experts' perceptions of the DAIS with respect to its potential adoption in their everyday life, i.e. in their consultation hours, we designed a survey and adopted constructs from technology acceptance, user satisfaction [30], and word-of-mouth research [31] and situation-service fit [32]. The information accessibility and information format constructs have been evaluated positive by the interviewed physicians, indicating an appropriate graphical layout of the information provided by DAIS. Moreover, the participating physicians would, in general, recommend DAIS to their colleagues. However, it should be mentioned that data-analytical DAIS used for predictions in the context of healthcare is critically discussed amongst health professionals and is still met with skepticism. Further research has to put more focus on additional collaboration with domain experts to enhance the DAIS with their expert knowledge on the one hand and to better meet the needs of physicians on the other hand. Moreover, further studies have to focus on the communication between physicians and their patients in rural areas through the DAIS. This motivates following discussion points:

1. How can trust of physicians and patients, i.e. namely obese children, in data-driven systems based on machine learning be enhanced?
2. How should a data-driven system be designed to enhance the communication between physicians and their patients in rural areas?
3. How can physicians, computer scientist and engineers collaborate in such a way that the developed data-driven decision

support system satisfies the needs of physicians and their patients in rural areas?

5 SUMMARY

The origin of obesity represents a complex health problem, which is already widely spread amongst children and adolescents, especially in rural areas. Even though many scientists and physicians developed various therapy programs, a well-defined solution using methods that do not rely on in-person services is still missing. With our research works, we introduced a patient-centric data-driven system using low-cost devices that allows to make predictions on performance and whether BMI will decrease in the future, before conducting a therapy. Results indicate that domain experts might be motivated to use data-driven systems as an additional clinical decision support in the treatment of obesity. However, critical discussion points arise regarding trust of domain experts in ML based systems and design of the communication between experts and patients in rural areas.

6 SHORT BIOGRAPHY

6.1 Nurten Öksüz

After studying business informatics at the Saarland University in Germany, she started as a PhD student at the Chair in Information and Service Systems at the Saarland University. Directed by Prof. Dr.-Ing. Wolfgang Maass, the chair deals with the development of data-driven services. She works as a researcher at the German Research Center for Artificial Intelligence (DFKI).

Research Interest. The author is doing research in the area of biosignal-based smart services, especially in the Health-IT and Smart Retail sector, using machine learning techniques.

Awards. She is a fellow of Software Campus, an elite funding program for developing young IT-project managers. The project "Predictive Analytics for Situation-Specific Recommender Systems" is carried out with Media-Saturn, Europe's leading specialty chain for electronics.

6.2 Wolfgang Maass

Wolfgang Maass is Professor of Business Administration, especially Business Informatics in Service Management, Professor of Computer Science (co-opted) at Saarland University, Scientific Director of the German Research Center for Artificial Intelligence (DFKI) and Associate Professor of Biomedical Informatics at Stony Brook University, NY. He studied computer science at the RWTH Aachen, as well as at Saarland University.

Research Interest. His field of research are information systems including Ubiquitous Information Systems with a focus on smart products, Internet of Things, intelligent information systems, conceptual modeling, electronic and knowledge markets.

Awards. His PhD in computer science was funded by a DFG scholarship from the graduate college "Cognitive Science".

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