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AI-Assisted Application for Pediatric Drug Dosing

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Abstract. Technology in the medical field is continuously advancing due to its numerous subdomains and the ever-growing medical needs of people. Information systems have become integral to doctors' daily routines in patient care, offering flexibility and support in repetitive tasks, thereby allowing more time for critical activities. This paper presents the implementation of a machine learning algorithm, leveraging natural language processing (NLP) and labeling techniques, to analyze medical leaflets from Romania. The aim is to assist pediatricians in determining appropriate treatment doses for children based on various parameters such as age, weight, and other significant factors.

Keywords. Medical leaflets, Machine Learning, spaCy, annotation, drugs

1. Introduction

The work of doctors can often be exhausting due to repetitive tasks that require executing numerous steps, significantly hindering the completion of medical actions in a short time. This effort can be quite substantial. In pediatric medicine, determining the correct doses of medications for children is crucial to ensuring treatment effectiveness and minimizing the risk of side effects. The significant differences in metabolism and drug response between children and adults further complicate this process. Machine learning algorithms have the potential to revolutionize this field, providing personalized and precise solutions for determining optimal doses, thereby enhancing patient care and reducing the burden on healthcare professionals.

The primary motivation for developing this application is to address the challenges and risks associated with pediatric medication dosing, which often requires careful consideration of various factors such as age, weight, and specific medical conditions. By automating and refining the dosing process, this AI-assisted tool aims to reduce human errors and provide personalized treatment recommendations.

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2. Domain Analysis

The integration of AI in healthcare has been explored extensively in recent years. Studies [1], [2], [3], [4], [5] have demonstrated the potential of AI in improving various aspects of medical care, including diagnostics, treatment planning, and patient monitoring. For instance, AI algorithms have shown high accuracy in diagnosing diseases from medical images, predicting patient outcomes, and identifying potential drug interactions.

[6] evaluates current pediatric precision dosing efforts, emphasizing their utility, longevity, and sustainability, and assesses the implementation process, addressing barriers and stakeholder engagement necessary for broader success in providing accurate and effective dosing for pediatric populations.

[7] highlights the emerging integration of artificial intelligence (AI) and machine learning (ML) with therapeutic drug monitoring (TDM) and model-informed precision dosing (MIPD), showcasing recent applications and discussing the potential benefits and challenges of using AI and ML to enhance precision dosing through advanced computational and pharmacometrics approaches.

In the context of pediatric medication dosing, existing solutions often rely on standard dosing guidelines, which may not account for individual patient differences. AI, particularly NLP, offers the ability to analyze vast amounts of medical literature and patient data to provide more tailored dosing recommendations.

3. Methods

The proposed solution leverages artificial intelligence (AI) and natural language processing (NLP) to address the challenge of accurately dosing medications for children. This is achieved through the development of a web-based application that processes and analyzes medical leaflets (prospectuses) available on the Romanian market. The core objective is to utilize advanced NLP algorithms to extract relevant dosing information, thus facilitating precise medication dosing tailored to pediatric patients.

In this study, we used a systematic approach to develop and evaluate a named entity recognition (NER) model. We used Doccano, an open-source text annotation tool, to label a corpus of approximately 900 paragraphs.

The application is designed to be user-friendly, enabling healthcare professionals and caregivers to easily input and retrieve dosing information (Figure 1).

The system architecture is designed around a client-server model, where the backend is responsible for processing data received from the client interface. Upon receiving transmitted information, the server utilizes a pre-trained Named Entity Recognition (NER) model to extract key details from the prescription text. Developed with spaCy, this NER model is adept at recognizing relevant labels and their relationships, enabling accurate and personalized medication recommendations based on the patient's specific data (Figure 2).

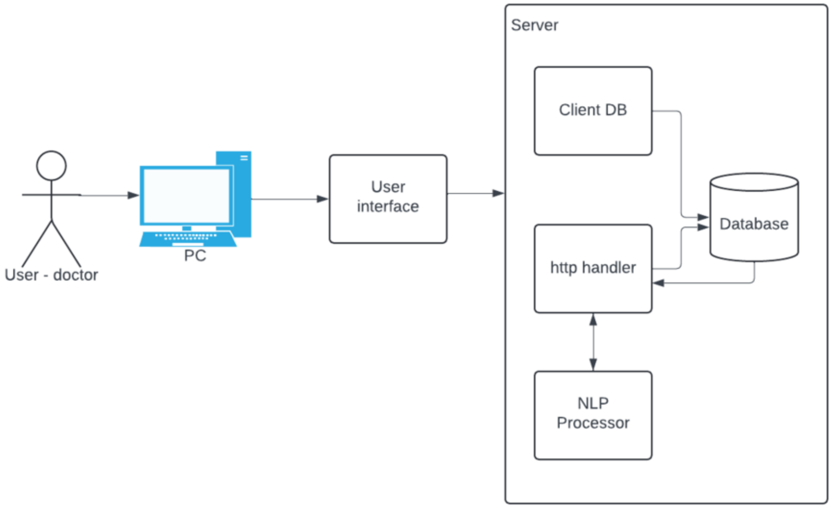

Figure 1 - System Architecture

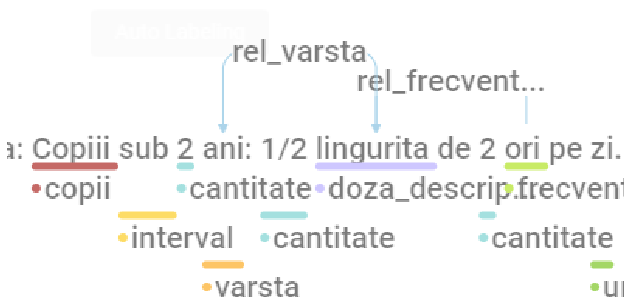

Figure 2 - Annotation phase

The doctor can prescribe a treatment directly within the application by entering the name of the desired medication. The application then provides a tailored recommendation, generated by a machine learning algorithm trained on extensive medication leaflets. This recommendation suggests the optimal dosage, carefully adjusted according to the patient's age and weight, ensuring a personalized and accurate prescription (Figure 3).

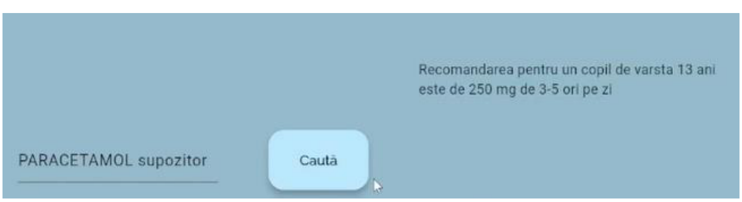

Figure 3 - Results in user interface

4. Results and Discussion

The application is tested using a dataset of pediatric patient records and compared against standard dosing practices. Metrics such as accuracy, precision, recall, and user satisfaction are used to assess the performance.

The discussion highlights the advantages of the AI-assisted approach, such as improved dosing accuracy and reduced risk of adverse drug reactions. Potential limitations and areas for future improvement are also discussed. For example, the algorithm's dependency on the quality and comprehensiveness of the input data, and the need for continuous updates to the knowledge base as new medical information becomes available.

4.1. Benefits for doctors

By automating medication dosage calculations, the system significantly reduces the risk of human errors that can occur due to the complexity of pediatric treatments. The algorithm analyzes each patient's clinical and pharmacological data to provide evidence-based dosage recommendations, ensuring a high level of accuracy and safety.

The system offers valuable decision support to doctors by providing relevant and up-to-date information on recommended dosages for each patient. This helps doctors make informed decisions based on concrete data and detailed analysis of each case, thereby improving the quality of medical care.

4.2. Benefits for patients

The algorithm allows for personalized treatments by adjusting dosages according to each patient's specific characteristics, such as age, weight, general health, and response to treatment. This leads to higher treatment efficacy and an improved medical experience for patients.

By reducing the risk of over- or under-dosing, the system enhances the safety of pediatric treatments. Precise and personalized dosage recommendations help prevent adverse effects and optimize therapeutic responses, ensuring safer and more effective treatment for each child.

4.3. Practical evaluation

To analyze the performance of our Named Entity Recognition (NER) algorithm, we collected 50 paragraphs and counted the total number of labels and the number of correctly identified labels by the algorithm.

Our algorithm correctly identified approximately 76% of the labels, suggesting that relationships between entities are more complex and may require more sophisticated models to capture accurately. To achieve greater accuracy in the future, we will aim to train the model with more medical leaflets.

4.4. Challenges

Identifying the period for which a treatment should be administered is a difficult process for a machine learning system. This must be determined together with the specialist doctor based on diseases, conditions, severity of the situation, symptoms, etc. Furthermore, a treatment that works excellently for one patient may yield poor results or worsen the situation for another patient, indicating a highly variable environment. One solution to this problem could be training the algorithm based on the patient's medical history and previous treatment responses to achieve the most personalized treatment plans possible.

Another challenge that complicated the implementation phase was accurately determining the age range to which the patient belongs. It is difficult to identify the age range of the patient, requiring additional steps, especially when the information includes both age and weight. This complicates the determination of correct dosages. A potential solution to this problem is to establish the labels and relationships between them as accurately as possible during the text annotation phase used for algorithm training.

5. Conclusions

By automating the dosing process and providing personalized recommendations, the application aims to improve patient safety and treatment outcomes.

Future work will focus on expanding the application's capabilities, such as incorporating more diverse medical data sources and refining the NLP models for better accuracy.

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