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AI-based relevance screening in Potential Technology Review to accelerate demand-pull innovation in medical technology

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Introduction

Starting from the clinical demand (rather than from technologies) to develop biomedical innovation lowers the risk of late failing. The recently published Potential Technology Review (PTR) procedure successfully utilizes text mining to identify relevant scientific publications containing demand-matching technological concepts. However, even PTR finally leaves several hundred publications for manual screening causing an expert workload of several days following the PICO review standard. But pace is crucial for innovating and therefore we propose a machine learning approach for automated relevance screening to reduce both manual workload and risk of bias as a novel stage in PTR.

Methods

To master the challenge of very limited training data in our oncological use case, a Support Vector Machine algorithm is implemented to solve the binary classification task (ir-/relevant) with bag-of-word text representation. Three training datasets of 120 publications each are subdivided into two parts: fixed 60 relevant publications (initial corpus of PTR) and three different samples of 60 irrelevant publications taken randomly from PTR's arbitrary literature search. The hyperparameter tuning for each training dataset results in three optimized classifiers to be evaluated with test data of 512 publications manually screened by an expert.

Results

The expert rated 39 publications of 512 as relevant. The three trained classifiers achieve a high classification performance with 91%/87%/95% micro-averaged F1 score. In detail, 74/100/46 out of 512 publications were classified as relevant containing 34/36/31 of the 39 relevant publications (46%/36%/66% precision, 87%/92%/79% recall). This reduces the manual screening workload by 86%/80%/91%.

Conclusion

The workload of final manual screening of publications in PTR can be substantially reduced using a machine learning-based approach for text classification by exploiting arbitrary literature search data of a Potential Technology Review. A more elaborated evaluation, also in terms of robustness and further test cases, is part of future work.

Cytomorphologic classification of leukocytes in Acute Myeloid Leukemia using deep learning

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Introduction

Acute Myeloid Leukemia (AML) is a neoplasm of the myeloid lineage whose diagnostic workup includes examination of blood smears and bone marrow samples under a high-resolution microscope. While other diagnostic modalities are intrinsically automated, cytomorphologic classification is still today performed by human examiners on a microscope. Recent advances in image recognition promise to offer support in this step of the diagnostic algorithm.

Methods

We compiled a database of single-cell leukocyte images taken at 100-fold magnification and oil immersion from 100 AML patients and 100 controls. Single-cell images were annotated according to a classification scheme inspired by routine practice comprising 15 morphlogical classes relevant in the diagnosis of AML by experienced examiners. In order to test annotation consistency, up to three independent annotations were performed. Overall, more than 18,000 cells were included into the dataset.
Using this dataset, a state-of-the-art convolutional neural network (CNN) was trained and evaluated.

Results

The network attains human levels of performance (ROC-AUC = 0.99) in reccognising blast cells characteristic of AML and atypical cells absent in normal blood smears. Most cell types of the morphological scheme are classified at a high level of accuracy. Analysis of the network suggests that image regions known to be relevant for cell differentiation contribute significantly to the classification decision taken.

Conclusion

Deep learning methods can successfully classify leukocytes from microscopic blood smear images, and recognise cells characteristic of AML at human-level performance. When trained on single-cell images, the network learns to focus on image regions known to be relevant in morphological examination. This opens up possibilities of further integration of cytomotphology with other methods relevant in leukemia diagnostics.

Exploiting the taxonomic structure of SNOMED CT concepts for machine learning using modified tree representations – A feasibility study

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Introduction

With the digitization of healthcare systems, the relevance of unified semantic standards is increasing. SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms) is one of the most comprehensive medical terminologies, which will be introduced in Germany. It contains hundreds of thousands of concepts and relationships organized in a taxonomic structure.
However, to make the data processable for machine learning tasks, preprocessing into meaningful representations is required.
Thus, we study the feasibility of transforming the SNOMED CT concepts into tree representations, calculating real-valued vectors with tree-edit-distances, and applying them to machine learning tasks.

Methods

We parse a concept as a graph by exploiting the structure defining ‘is a’-relationships and transform it to a tree. For the vector space embedding, we select prototypes among the set of trees to create tree-edit-distances with and without modifications approximating highly complex graph-edit-distances. We evaluate these vector space embeddings of up to 7000 concepts with a label classification task (predicting UMLS (Unified Medical Language System) semantic types as higher level classifications of concepts). As an outlook, we exemplarily apply the embeddings to a patient state prediction task (predicting ICD (International Classification of Diseases) diagnoses codes for a specific visit based on previous visits) and compare it to state-of-the-art approaches (CUI2VEC, Med2Vec, Metapath2Vec, Noede2Vec, Pointcaré).

Results

The modified tree-edit-distances show a good approximation to graph-edit-distances in a random sample test. For the label classification, the approach using modified tree-edit-distances is with 63% precision superior to the approach without modifications (58%), while the aforementioned approaches reached 4% to 86%. Even the patient state prediction shows promising results with accuracies close to recent work.

Conclusion

Our findings show that exploiting the taxonomic structure with modified tree representations enables SNOMED CT annotated health data for machine learning tasks as future contribution to computer-based support of diagnoses and therapies.

The PostStroke-Manager – An innovative digital and sensor-based concept allowing patient-centered stroke aftercare

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Introduction

During the last decade, acute stroke treatment has improved substantially, resulting in decreased case fatality and better functional outcome. Recently, the focus in stroke management has moved towards secondary prevention and reduction of residual neurological deficits. Further improvements could be hindered by a lack of concepts for stroke aftercare. To overcome this limitation, innovative concepts applying information technology (IT) are needed which take the multidisciplinary setting in post-acute stroke care into account.

Methods

In the project PostStroke-Manager, stroke physicians and IT specialists develop a comprehensive digital approach that focusses on the stroke patient with individual symptoms, risk factors and therapy goals utilizing innovative data usage and integration concepts. To achieve a solution suitable for everyday use, patients, insurances, interest groups, IT infrastructure and care providers are involved in the development process. In a feasibility study, stroke patients will be equipped with mobile sensor technology and tablets including an application. Furthermore, patients will undergo psychometric assessment addressing outcome measures such as quality of life and patient empowerment. Two stroke pilots will be implemented to provide support through personal contact.

Results

In the patient application, acquired data is bundled and integrated. The other parties in stroke aftercare, e.g. stroke pilots, general practitioners and therapists, connect to the platform with applications for tablets or browsers and – with patients' consent – are given access to relevant data and analyses. The communication of all parties involved is organized via a patient-centered timeline, which documents the patient's path in an interdisciplinary manner. In addition, an adaptive information tool which takes individual conditions into account, provides access to medical and care-related content.

Conclusion

Concerning the need for strategies during the naturally complex stroke aftercare, the project PostStroke-Manager has begun to establish an e-health-based solution, combining apps and web applications with sensor technologies and an interdisciplinary communication platform.

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Machine learning based identification of elderly persons with cognitive impairment using dynamic time warping

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Introduction

Cognitive changes in general occur with normal aging. This may lead to the prevalence and effect of age associated diseases. The understanding and identification of these age-related cognitive impairments is an important aspect in elderly population. This leads in the simple case, supporting a functional independence of the elderly and in a complex case, an early identification of dementia in advance. One important change with normal aging is the decline in gait functionality. The decline in gait is more visible in the elderly with more cognitive impairment during dual cognitive tasks, multi-tasking exercises.

Methods

For the classification of the healthy elderly from the elderly having cognitive impairments, the gait data of the elderly is acquired. 3D based pose estimation using the depth data is performed. Gait parameters and gait cycles of the individual elderly are estimated. In this paper, Dynamic Time Warping (DTW) algorithm is used to compare the patterns of the gait cycles of the individual in different trails such as Regular Gait 1 (RG1), Regular Gait 2 (RG2), Counting Backward 1 (CB1), Counting Backward 3 (CB3), Fast Gait (FG) and Words with Special Letters (WSPL). The identified cross levels along with the estimated gait parameters are used for training the machine learning algorithm. Support Vector Machines (SVM) were used for the classification of the elderly persons with or without cognitive impairments.

Results

The experiment results proved that such a classification in future help in the identification of dementia in advance. Proposed SVM approach classify the Cognitive Healthy Individuals (CHI), possible Mildly Cognitively Impaired persons (pMCI) and Mildly Cognitively Impaired persons (MCI) and achieved a moderate accuracy of classifying the individual classes ranging from 74.6 % - 87.3 %.

Conclusion

The results demonstrate that the extracted DTW features play a crucial role in the classification purpose but may not be sufficient.

Data recording framework for physiological and surgical data in operating theatres

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Introduction

Integrated operating rooms typically connect medical devices providing the clinical user a complete control over environment, device setting and digital management of intervention-related data. Consequently, the opportunity to analyze and present data from different perspectives and with different objectives has arisen. The available integrated ORs are so far designed as closed systems, thus connecting co-existing systems from different manufactures e.g. anesthesia machines and surgical devices is demanding.

Methods

In this project, the patient data from anesthesiology and patient monitor (patient view) is included and combined with device data from the surgical side (instrument view) (e.g. electrosurgical unit, laparoscopic camera and Insufflator). The aim is to find out if surgical actions affect the physiological situation of patients and how to employ this knowledge for assisting the surgical team and improve patient safety.

Results

The study is performed on laparoscopic procedures, and the data is going to be recorded at the Schwarzwald-Baar Klinikum (SBK) in Villingen-Schwenningen (Germany). Therefore, this part of the project focuses on the overall architecture for collecting data at the operating theater in the SBK. In this work, (i) the system architecture (i.e. hardware components), (ii) software architecture and (iii) required protocols for synchronous recording of data in the OR are described.

Conclusion

Clinical data recording inside operating rooms is a challenging task due to the special requirements that need to be considered and the manufacture-dependent communication protocols used by medical devices. In this work, system architecture and software architecture for recording data from multiple medical devices inside the OR at the SBK were presented. The System is ready to use and allows synchronous recording of almost all data available in the OR.