Selected Ph.D. Thesis Abstracts

This Ph.D. thesis abstracts section selected theses defended during the period of August 2017 to July 2018. These submissions cover numerous research and applications under intelligent informatics such as robotics, fuzzy systems, semantic query processing system, recommender system, bioinformatics, image processing, transfer learning, machine learning in healthcare, cyber-physical systems, game theory and text mining, etc. Fig.1 presents the word cloud of those abstracts.

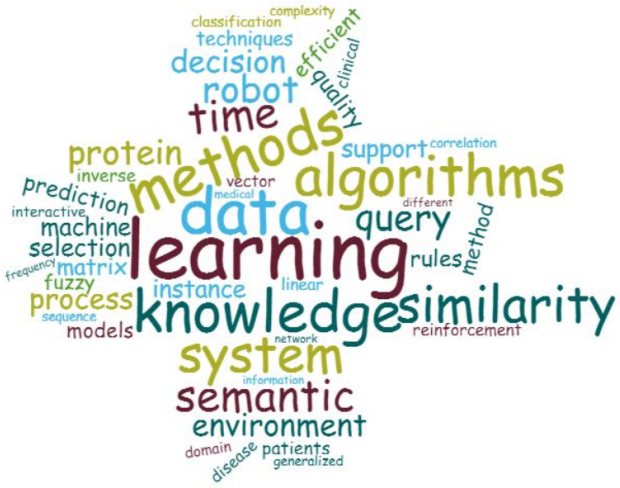

Fig. 1. Word Cloud of the Ph.D Thesis Abstracts

Using Rules of Thumb to Repair Inconsistent Knowledge

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AN important challenge that arises when trying to create a knowledge base from raw data is the inconsistency introduced by the integrity constraints that are imposed. The goal is then to restore consistency in the knowledge base. A common approach to achieve this goal is to find some sort of minimal repair. While this strategy is reasonable in the absence of any background knowledge, in real-world applications, additional knowledge about the system being modelled is often accessible. In this thesis, we study the use of such additional knowledge to repair inconsistencies in different types of systems. We encode this knowledge in the form of rules of thumb that act as "soft constraints" in a system.

First, we study the impact of using rules of thumb to repair inconsistencies that are found in taxonomies that were automatically extracted from text corpora found on the web. We use Markov logic to encode this problem and propose MAP inference as a base method to generate minimal repairs. We encode dependencies between taxonomy facts in the form of rules of thumb, such as: "if a given fact is wrong then all facts that have been extracted from the same sentence are also likely to be wrong". We show that, by adding these rules, we generate more accurate repairs than minimal repairs.

Second, we introduce a rules of thumb approach to repair inconsistent answer set programs. Answer set programming (ASP) is a form of declarative programming that is used to model various systems. We consider the scenario where additional knowledge that could be encoded as rules of thumb is available about the studied domain, but no training data is available to learn how these rules interact. The main problem we address is whether we can still aggregate the rules of thumb in the absence of training data in order to generate more plausible repairs than minimal repairs. In addition to standard aggregation techniques, we present a novel statistical approach that assigns weights to these rules of thumb, by sampling from a pool of possible repairs. We show in our experiments that our Z-score approach outperforms all the other repair methods in terms of F_1 score and Jaccard index, including the minimal repair approach.

Third, we tackle the problem of repairing inconsistencies that arise when multiple treatments are simultaneously needed for comorbid patients. In this application, we encode preferences as rules of thumb that contain information in the form of drug-drug interactions. We show in a case study encoded in ASP that this method generates more preferred treatments than standard approaches. The second method we propose to find treatments for patients with comorbid diseases is a fully data driven approach using word-based and phrase-based alignment methods. In this approach, we explore the use of rules of thumb that incorporates drug interactions penalty and procedure popularity scores. We show that the combined treatments that are found when adding rules of thumb to these word-based and phrase-based alignment methods are more plausible than using standard translation approaches.

Optimization of Semantic Cache Query Processing System

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HIGH availability and low latencies of data are major requirements in accessing contemporary large and networked databases. However, it becomes difficult to achieve high availability and reduced data access latency with unreliable connectivity and limited bandwidth. These two requirements become crucial in ubiquitous environment when data is required all the times and everywhere. Cache is one of the promising solutions to improve availability and reduce latencies of remotely accessed data by storing and reusing

the results of already processed similar queries. Conventional cache lacks in partial reuse of already accessed data, while semantic cache overcomes the limitation of conventional cache by reusing the data for partial overlapped queries by storing description of queries with results. There is a need of an efficient cache system to improve the availability, reduce the data access latencies and the network traffic by reusing the already stored results for fully and partially overlapped queries. An efficient cache system demands efficient query processing and cache management. In this study, a qualitative benchmark with four qualities as Accuracy, Increased Data Availability, Reduced Network Traffic and Reduced Data Access Latency is proposed to evaluate a semantic cache system, especially from query processing point of view. The qualitative benchmark is then converted into six quantitative parameters (Semantics and Indexing Structure IS, Generation of Amending Query GoAQ, Zero Level Rejection ZLR, Predicate Matching, SELECT_CLAUSE Handling, Complexity of Query Matching CoQM) that help in measuring the efficiency of a query processing algorithm. As the result of evaluation, it is discovered that existing algorithms for query trimming can be optimized. Architecture of a semantic cache system is proposed to meet the benchmark criteria. One of the important deficiencies observed in the existing system is the storage of query semantics in segments (indexing of the semantics) and the organization of these segments. Therefore, an appropriate indexing scheme to store the semantics of queries is needed to reduce query matching time. In the existing indexing schemes the number of segments grows faster than exponential, i.e., more than 2^n. The semantic matching of a user query with number of segments more than 2^n will be exponential and not feasible for a large value of n. The proposed schema-based indexing scheme is of polynomial time complexity for the matching process. Another important deficiency observed is the large complexity of query trimming algorithm which is responsible to filter the semantics of incoming query into local cache and remote query. A rule based algorithm is proposed for query trimming that is faster and less complex than existing satisfiability/implication algorithms. The proposed trimming algorithm is more powerful in finding the hidden/implicit semantics, too. The significance of the proposed algorithms is justified by case studies in comparison with the previous algorithms and correctness is tested by implementing a prototype. The final outcomes revealed that the proposed scheme has achieved sufficient accuracy, increased availability, reduced network traffic, and reduced data access latency.

Investigating Protein Semantic Similarity Measurement and its Correlation with Sequence Similarity

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PROTEIN sequence similarity is commonly used to compare proteins and to search for proteins similar to a query protein. With the growing use of biomedical ontologies, especially Gene Ontology (GO), semantic similarity between ontology terms, proteins and genes is getting attention of researchers. Protein semantic similarity measurement has many applications in bioinformatics, including prediction of protein function and protein-protein interactions. Semantic similarity measures were initially proposed by Resnik, Jiang and Conrath, and Lin. Recent measures include Wang and AIC. The question whether the semantic similarity has strong correlation with sequence similarity, has been addressed by some authors. It has been reported that such correlation exists, and it has been used for the evaluation of semantic similarity computation methods as well as for protein function prediction. We investigate the correlation between semantic similarity and sequence similarity through graphs, Persons correlation coefficient and example proteins. We find that there is no strong correlation between the two similarity measures. Pearsons correlation coefficient is not sufficient to explain the nature of this relationship, if not accompanied by graph analysis. We find that there are several pairs with low sequence similarity and high semantic similarity, but very few pairs with high sequence similarity and low semantic similarity. Interestingly, the correlation coefficient depends only on the number of common GO terms in proteins under comparison. We propose a novel method SemSim for semantic similarity measurement. It addresses the limitations of existing methods, and computes similarity in two steps. In the first step, SimGIC like approach is used where contribution of common ancestors is divided by contribution of all ancestors. In the second step, we use two new factors: Specificity computed from ontology based information content, and Uniqueness computed from annotation based information content. The final result, after applying these two factors, makes clear distinction between the generalized and specialized terms. When semantic similarity is used for searching proteins from large databases, the speed issue becomes significant. To search for proteins similar to a query protein having m annotations, from the database of p proteins, p X m X n X g comparisons would be required. Here n is the average annotations per protein, g is the complexity of GO term similarity computation algorithm, and it is assumed that each term of one protein is compared with each term of the other. We propose a method SimExact that is suitable for high speed searching of semantically similar proteins. Although SimExact works on common terms only, our experiments show that it gives correct results required for protein semantic searching. SimExact can be used as a pre processor, generating candidate list for the existing methods, which proceed for further computation. We provide online tool that generates a ranked list of the proteins similar to a query protein, with a response time of less than 8 seconds in our setup. We use SimExact to search for protein pairs having high disparity between semantic similarity and sequence similarity. SimExact makes such searches possible, which would be NP-hard otherwise.

Time-Efficient Variants of Twin Support Vector Machine with Applications in Image Processing

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HUMAN beings can display intelligent behavior by learning from their experiences. The aim of learning is to generalize well, which essentially means to establish similarity between situations, so that the rules which are applicable in one situation can be applied or extended to other situations. Machine learning enables a machine to learn from empirical data and builds models to make reliable future predictions. It is categorized as supervised and unsupervised learning. Support Vector Machines and Twin Support Vector Machine (TWSVM) are distinguished works in supervised learning. This research work attempts to develop machine learning algorithms which could deliver better results than well-established methodologies. Our focus is on development of time-efficient learning algorithms, with good generalization ability, and to apply them for image processing tasks.

To improve the time complexity of nonparallel-hyperplane classifiers, this thesis first proposes a set of algorithms termed as Improvements on ν-Twin Support Vector Machine. The first version of our classification algorithm solves an efficient, smaller-sized quadratic programming problem (QPP) and an unconstrained minimization problem (UMP), instead of solving a pair of expensive QPPs. Second (and faster) version modifies first problem as minimization of unimodal function, for which line search methods can be used. Experimental results proved that proposed algorithms have good generalization ability and are extended to handle multi-category classification problems. Two more classifiers i.e. Angle-based Twin Parametric-Margin Support Vector Machine (ATP-SVM) and Angle-based Twin Support Vector Machine (ATWSVM), have been proposed, which aim to maximize the angle between normal vectors to the two nonparallel-hyperplanes, so as to generate larger separation between the two classes. ATP-SVM solves only one modified QPP with fewer representative patterns and avoids explicit computation of matrix inverse in the dual problem. This improves learning time of our algorithm. ATWSVM is a generic algorithm to improve efficiency of any existing binary nonparallel-hyperplane classifier.

This thesis proposes Ternary Support Vector Machine to separate data belonging to three classes and its multi-category classification algorithm, Reduced Tree for Ternary Support Vector Machine. Here, classes are organized in the form of ternary tree. Most of the real world problems deal with multiple classes, so this work proposes Ternary Decision Structure and Binary Tree of classifiers, that can extend existing binary classifiers to multi-category framework. They are more efficient than the classical multi-category classification approaches. This work proposes development of unsupervised clustering algorithm termed as Tree-based Localized Fuzzy Twin Support Vector Clustering (Tree-TWSVC), which recursively builds a cluster model as a Binary Tree. Here, each node comprises of a novel classifier termed as Localized Fuzzy TWSVM. Tree-TWSVC has efficient learning time, achieved due to tree structure and its formulation leads to solving a series of system of linear equations.

Extensive experiments have been carried out to prove the efficacy of proposed algorithms using synthetic and benchmark real-world datasets. Our algorithms have outperformed state-of-the-art methods and results presented in the thesis demonstrate their effectiveness and applicability. Our algorithms have been applied to perform image processing tasks like content based image retrieval, image segmentation, handwritten digit recognition. (http://sau.int/pdf/PoojaSaigal_PhD_Thesis.pdf)

APPLICATION OF GENERALIZED INVERSES ON SOLVING FUZZY LINEAR SYSTEMS

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THE topic of this thesis is the presentation of the original method for solving fuzzy linear systems (FLS) using generalized inverses of a matrix. Development of science and technology has motivated investigation of methods for solving fuzzy linear systems, which parameters are rather represented by fuzzy numbers than numbers. Buckley and Qu observed the fuzzy linear system in the form of $\tilde{A}\tilde{X} = \tilde{Y}$, at the end of the last century. Further, Friedman et al. proposed a method for solving a squared FLS, in the form of $A\tilde{X} = \tilde{Y}$, which matrix A is a matrix of real coefficient and $\tilde{X}$ and $\tilde{Y}$ are fuzzy numbers vectors, while $\tilde{X}$ is unknown. Moore and Penrose presented generalized inverses of a matrix, in the middle of the last century. The most popular generalized inverses are $\{1\}$, $\{2\}$, $\{3\}$, $\{4\}$, $\{5\}$, $\{1^k\}$ and $\{5^k\}$ - inverse. They are used individually or in the combination with each other. The most applicable generalized inverse is the Moore-Penrose inverse of a matrix, which is defined as a unique solution of the system of four matrix equations. The goal of this thesis is to present the method which formulates a necessary and sufficient condition for the existence of solutions of fuzzy linear systems and gives the exact algebraic form of any solution. In addition, an efficient algorithm for determination all solutions of fuzzy linear systems is presented. In this thesis fuzzy linear systems, in the form of $A\tilde{X} = \tilde{Y}$ where real matrix A can be dimension of $m \times n$ or $n \times n$ and singular or regular, are solved. In the purpose of solving FLS where the real matrix A is mxn, the new, original method is based on generalized inverse - the Moore-Penrose inverse of a matrix. Especially, this method uses generalized $\{1, 3\}$-inverse or $\{1, 4\}$-inverse when the arbitrary, real coefficient matrix of FLS is the full rank matrix by columns or rows. The efficient algorithm for this method is presented as well as solving of the example addressed multi-criteria decision making problems. The efficient method for solving a singular, nxn fuzzy linear system, $A\tilde{X} = \tilde{Y}$, where the coefficient matrix A is a real matrix, singular or regular, using the block structure of the group inverse or any 1-inverse. Based on the presented necessary and sufficient condition for the existence of a solution, the general solution of a square FLS is obtained. Finally, infinitely many solutions of a singular FLS are presented through many interesting examples. (http://www.ftn.uns.ac.rs/539013902/disertacija)

STUDY OF INSTANCE SELECTION METHODS

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NEW challenges have arisen for learning algorithms, as the data bases that are used for training systems have grown in size. Even a new name has been coined for referring to the problems linked to this: big data. But not only for learning algorithms, other steps of the "Knowledge Discovery in Databases" process suffer from the same problems when the data bases' size grows. For example, preprocessing techniques which represent one of the very first phases of KDD and their purpose is to adjust data sets to make their subsequent treatment easier.

Preprocessing methods are essential for achieving accurate models, it should never be forgotten that the quality of a trained model is strongly influenced by the quality of the data used in the training phase. One of these techniques, instance selection, is used to reduce the size of a data set by removing the instances that do not provide valuable information to the whole data set. The benefits of the instance selection methods are twofold: on the one hand, the reduction of data sets' size makes easier the training process of different learners; on the other hand, these techniques can remove harmful instances such as noise or outliers.

This thesis focuses on the study of instance selection methods. State-of-the-art techniques were analysed and new methods were designed to cover some of the areas that had not, up until now, received the attention they deserve, more precisely they were: instance selection for regression (i) and instance selection for big data classification (ii).

Regarding to the former (i), instance selection has been extensively researched for classification but, unfortunately, not for regression. This fact can be explained because the selection of the instances in regression is much more challenging than in classification. While in the typical classification problems the membership of an instance to a class is sharply defined (an instance belongs or not to a class, and if it belongs to a class, it does not belong to the others) which facilitates the selection process, in regression there is no concept of class that can be used to guide the performing of the algorithms.

With respect to instance selection for big data classification (ii), the main drawback is the complexity of the existing methods, commonly quadratic or even higher. Instance selection has shown itself to be effective for reducing the size of the data sets while preserving their predictive capabilities. The problem that emerges at this point, is the high computational complexity that these methods have. Recently some studies have focused on it, however more scalable methods are required for instance selection with the aim of tackling the current size of data sets. In one of the chapters of the thesis, the locality sensitive hashing technique was used for designing two new instance selection algorithms of linear complexity that can be used in big data environments.

Finally, the future lines of the thesis focus on instance selection for multi-label learning. This new scenario makes the instance selection process much more challenging. (http://hdl.handle.net/10259/4830)

An Intelligent Recommender System Based on Short-term Disease Risk Prediction for Patients with Chronic Diseases in a Telehealth Environment

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CLINICAL decisions are usually made based on the practitioners experiences with limited support from data-centric analytic process from medical databases. This often leads to undesirable biases, human errors and high medical costs affecting the quality of services provided to patients. Recently, the use of intelligent technologies in clinical decision making in the telehealth environment has begun to play a vital role in improving the quality of patients lives and reducing the costs and workload involved in their daily healthcare. In the telehealth environment, patients suffering from chronic diseases such as heart disease or diabetes have to take various medical tests (such as measuring blood pressure, blood sugar and blood oxygen, etc). This practice adversely affects the overall convenience and quality of their everyday living.

In this PhD thesis, an effective recommender system is proposed that utilizes a set of innovative disease risk prediction algorithms and models for short-term disease risk prediction to provide chronic disease patients with appropriate recommendations regarding the need to take a medical test on the coming day.

The input sequence of sliding windows based on the patients time series data is analyzed in both the time domain and the frequency domain. The time series medical data obtained for each chronicle disease patient is partitioned into consecutive sliding windows for analysis in both the time and the frequency domains. The available time series data are readily available in time domains which can be used for analysis without any further conversion. Yet, for data analysis in the frequency domain, Fast Fourier Transformation (FFT) and Dual-Tree Complex Wavelet Transformation (DTCWT) are applied to convert the data into the frequency domain and extract the frequency information.

In the time domain, four innovative predictive algorithms C Basic Heuristic Algorithm (BHA), Regression-Based Algorithm (RBA) and Hybrid Algorithm (HA) as well as a structural graph-based method (SG) C are proposed to study the time series data for producing recommendations. While, in the frequency domain, three predictive classifiers C Artificial Neural Network, Least Squares-Support Vector Machine, and Naive Bayes C are used to produce the recommendations. An ensemble machine learning model is utilized to combine all the used predictive models and algorithms in both the time and frequency domains to produce the final recommendation.

Two real-life telehealth datasets collected from chronic disease patients (i.e., heart disease and diabetes patients) are utilized for a comprehensive experimental evaluation in this study. The results ascertain that the proposed system is effective in analyzing time series medical data and providing accurate and reliable (very low risk) recommendations to patients suffering from chronic diseases such as heart disease

and diabetes.

This research work will help provide a high-quality evidence-based intelligent decision support to clinical disease patients in significantly reducing their workload in medical checkups which otherwise have to be conducted every day in a telehealth environment. (https://drive.google.com/open?id=1Q0GrtPrCUf1ev8SdpdsvP2UIzxOpN3G-)

DATA-DRIVEN ANALYTICAL MODELS FOR IDENTIFICATION AND PREDICTION OF OPPORTUNITIES AND THREATS

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DURING the lifecycle of mega engineering projects such as: energy facilities, infrastructure projects, or data centers, executives in charge should take into account the potential opportunities and threats that could affect the execution of such projects. These opportunities and threats can arise from different domains; including for example: geopolitical, economic or financial, and can have an impact on different entities, such as, countries, cities or companies. The goal of this research is to provide a new approach to identify and predict opportunities and threats using large and diverse data sets, and ensemble Long-Short Term Memory (LSTM) neural network models to inform domain specific foresights. In addition to predicting the opportunities and threats, this research proposes new techniques to help decision-makers for deduction and reasoning purposes. The proposed models and results provide structured output to inform the executive decision-making process concerning large engineering projects (LEPs). This research proposes new techniques that not only provide reliable time-series predictions but uncertainty quantification to help make more informed decisions. The proposed ensemble framework consists of the following components: first, processed domain knowledge is used to extract a set of entity-domain features; second, structured learning based on Dynamic Time Warping (DTW), to learn similarity between sequences and Hierarchical Clustering Analysis (HCA), is used to determine which features are relevant for a given prediction problem; and finally, an automated decision based on the input and structured learning from the DTW-HCA is used to build a training data-set which is fed into a deep LSTM neural network for time-series predictions. A set of deeper ensemble programs are proposed such as Monte Carlo Simulations and Time Label Assignment to offer a controlled setting for assessing the impact of external shocks and a temporal alert system, respectively. The developed model can be used to inform decision makers about the set of opportunities and threats that their entities and assets face as a result of being engaged in an LEP accounting for epistemic uncertainty.

TEACHING ROBOTS WITH INTERACTIVE REINFORCEMENT LEARNING

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INTELLIGENT assistive robots have recently taken their first steps toward entering domestic scenarios. It is expected that they perform tasks which are often considered rather simple for humans. However, for a robot to reach human-like performance diverse subtasks need to be accomplished in order to satisfactorily complete a given task.

An open challenging issue is the time required by a robot to autonomously learn a new task. A strategy to speed up this apprenticeship period for autonomous robots is the integration of parent-like trainers to scaffold the learning. In this regard, a trainer guides the robot to enhance the task performance in the same manner as caregivers may support infants in the accomplishment of a given task. In this dissertation, we focus on these learning approaches, specifically on interactive reinforcement learning to perform a domestic task.

First, we investigate agent-agent interactive reinforcement learning. We use an artificial agent as a parent-like trainer. The artificial agent is previously trained by autonomous reinforcement learning and afterward becomes the trainer of other agents. This interactive scenario allows us to experiment with the interplay of parameters like the probability of receiving feedback and the consistency of feedback. We show that the consistency of feedback deserves special attention since small variations on this parameter may considerably affect the learner's performance. Moreover, we introduce the concept of contextual affordances which allows reducing the state-action space by avoiding failed-states, i.e., a group of states from which it is not possible to reach the goal state. By avoiding failed-states, the learner-agent is able to collect significantly more reward. The experiments also focus on the internal representation of knowledge in trainer-agents to improve the understanding of what the properties of a good teacher are. We show that using a polymath agent, i.e., an agent with more distributed knowledge among the states, it is possible to offer better advice to learner-agents compared to specialized agents.

Thereafter, we study human-agent interactive reinforcement learning. Initially, experiments are performed with human parent-like advice using uni-modal speech guidance. We observe that an impoverished speech recognition system may still help interactive reinforcement learning agents, although not to the same extent as in the ideal case of agent-agent interaction. Afterward, we perform an experiment including audiovisual parent-like advice. The set-up takes into account the integration of multi-modal cues in order to combine them into a single piece of consistent advice for the learner-agent. Additionally, we utilize contextual affordances to modulate the advice given to the robot to avoid failed-states and to effectively speed up the learning process. Multi-modal feedback produces more confident levels of advice allowing learner-agents to benefit from this in order to obtain more reward and to gain it faster.

This dissertation contributes to knowledge in terms of studying the interplay of multi-modal interactive feedback and contextual affordances. Overall, we investigate which parameters influence the interactive reinforcement learning process and show that the apprenticeship of reinforcement learning agents can be sped up by means of interactive parent-like advice, multi-modal feedback, and affordances-driven environmental

models. (http://ediss.sub.uni-hamburg.de/volltexte/2017/8609/pdf/Dissertation.pdf)

Fast, Real-Time Robot Navigation in Initially Unknown Environments via Cross-Domain Transfer Learning of Options

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AUTONOMOUS navigation is a critical aspect of operations performed by mobile robots in numerous applications such as domestic vacuum cleaning, autonomous vehicle driving, robot-based warehouse inventory management, and, critical applications such as unmanned search and rescue, and extraterrestrial exploration. The main problem in autonomous navigation is to enable a robot to determine a collision free path between its start and goal locations while reducing the amount of energy and/or time required to move along that path, and, while satisfying constraints such as maintaining a minimum clearance with obstacles along the path. Autonomous navigation is further complicated in most real-life situations as robots sensors have limited range and the robot might not have access to an a priori or accurate map of the entire environment. Consequently, robots have to make navigation decisions based on the limited information from the environment in their immediate vicinity perceived through their sensors. Unfortunately, making decisions with limited environment information can either require time- and computationally-intensive, motion planning calculations to navigate efficiently, or, result in time- and energy-wise inefficient navigation maneuvers if the robot uses naive motion planning techniques. To address this robot navigation decision making problem in an efficient manner, we propose to use a machine learning technique called transfer learning which enables a robot to navigate efficiently in complicated environments by reusing its previous knowledge acquired from human demonstrations or through navigation in past environments. In this dissertation, we have proposed two techniques - the first technique uses a concept called experience-based learning that enables a robot to reuse learned navigation maneuvers from past environments to navigate in new environments, albeit with obstacle boundary patterns similar to those encountered in the past environments. In the second technique, we generalize this concept by relaxing the constraint that obstacle boundary patterns have to be similar and present the main technique of this dissertation called Semi-Markov Decision Processes with Uncertainty and Transfer (SMDPU-T). In the second part of this dissertation, we proposed three techniques to enhance the performance of the SMDPU-T algorithm from different aspects by utilizing inverse reinforcement learning, unsupervised learning and deep reinforcement learning. All the proposed techniques in this dissertation were implemented either on a simulated or a physical mobile, four-wheeled robot called Coroware Corobot or Turtlebot which showed that the robot using our proposed techniques could navigate successfully in new environments with previously un-encountered obstacle boundary geometries. Our experimental results on simulated robots within Webots simulator illustrate that SMDPU-T takes 24% planning time and 39% total time to solve same navigation tasks while, our hardware results on a Turtlebot robot indicate that SMDPU-T on average takes 53% planning time and 60% total time as compared to a recent, sampling-based path planner. As the final contribution of this dissertation, we extended the proposed path planning approach from a single robot to a multi-robot system with multiple ground robots, that are able to learn efficient navigation maneuvers across different environments from each others past navigation experiences through a robot cloud-like infrastructure. (https://unomaha.box.com/s/74hadlsgm4nru3a005zhlv5kaeufiphl)

Innovative Machine Learning Methods for Demand Management in Smart Grid Market

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SMART Grid has been widely acknowledged as an efficient solution to the current energy system. Smart Grid market is a complex and dynamic market with different types of consumers and suppliers under an uncertain environment. An efficient management of Smart Grid market can benefit Smart Grid in multiple aspects, including reducing energy cost, improving energy efficiency and enhancing network reliability. This thesis focuses on improving demand management in Smart Grid market through developing innovative machine learning methods.

Firstly, this thesis studies Smart Grid market and proposes an intelligent broker model for Smart Grid market management. In the proposed broker designs, the challenges that a smart broker faces in Smart Grid market are comprehensively considered, and an adaptive and systematic model is constructed to surmount the challenges. Experimental results demonstrate that the proposed broker model can not only make much profit but also keep a good supply-demand balance. Secondly, this thesis studies how to accurately predict power demand of Smart Grid considering customer behaviors. A sparse Continuous Conditional Random Fields(sCCRF) model is proposed to explore customer behaviors. A load forecasting method through learning customer behaviors (LF-LCB) is proposed to effectively predict the demand of Smart Grid. Generally, learning customer behaviors to aggregate customers can assist decision makings towards various customers in a complex market environment. Thirdly, thesis studies effective renewable energy prediction methods through deep learning. A Deep Regression model for Sequential Data (DeepRSD) is proposed for renewable energy prediction. An alternative dropout is also proposed to effectively improve the generalization of DeepRSD. DeepRSD shows two major advantages over other known methods. 1) DeepRSD can simultaneously represent step features and temporal information. 2) DeepRSD has a strong nonlinear presentation capacity to achieve a good performance without feature engineering. Fourthly, thesis investigates state-of-the-art time-series prediction models and proposes a new effective model for time-series prediction,

applying to demand prediction in Smart Grid market. The proposed model is Sparse Gaussian Conditional Random Fields (SGCRF) on top of Recurrent Neural Networks (RNN), short as CoR. CoR integrates the advantages of RNN and SGCRF and shows excellent performance in demand prediction. CoR can effectively make use of temporal correlations, nonlinearities and structured information in time-series prediction. With sufficient experiments and analysis, this thesis concludes that CoR can be a new effective model for time-series prediction in Smart Grid and broad domains. In summary, this thesis proposes several effective machine learning methods to ameliorate demand management in Smart Grid market. The proposed machine learning methods not only contribute to effective demand management of Smart Grid market in practice, but also contribute to machine learning research, as they can be applied to broad domains.

DISCOVERY OF HIGH QUALITY KNOWLEDGE FOR CLINICAL DECISION SUPPORT SYSTEM BY APPLYING SEMANTIC WEB TECHNOLOGY

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WHILE the discovery of new clinical knowledge is always a good thing, it can lead to difficulties. Health experts are required to actively ensure they are informed about the latest accurate knowledge in their field. Many health experts already have access to Clinical Decision Support Systems (CDSSs). These systems aid health experts in making decisions by providing clinical knowledge. CDSS is helpful, but often has issues with the quality of knowledge extracted from knowledge sources (KSs) for decision making. Discovery of high quality clinical knowledge to support decision making is difficult. This issue is partly due to the enormous amount of research, guideline data and other knowledge published every year. Available KSs (e.g PubMed, Google scholar) are very diverse in terms of formats, structure, and vocabulary. Clinical knowledge may need to be extracted from these diverse locations and sources. To facilitate this task, many health experts focus on developing methods to manage and analyze clinical knowledge in this changeable environment. Most of KSs suffer from a lack of proper mechanism for identifying high quality knowledge. For example the PubMed search engine does not fully check some important knowledge quality metrics (QMs) such as citation, structure, accuracy and relevancy. This research has potential to make decisions easier, save time, and in turn allows the CDSSs operate more effectively. The objective of this research is to propose a knowledge quality assessment (KQA) approach to discover the high quality clinical knowledge needed for the purpose of decision making. Semantic Web (SW) technology has been used in the approach to assess how qualified knowledge is about given query. The candidate knowledge QMs were identified from related work to improve assessment of knowledge quality in CDSSs. By running a survey, the candidate knowledge QMs were reviewed and rated by health experts. Based on the survey results the knowledge QM measurements were proposed. While at an elementary stage and considered to be a proof of concept, this research offers fresh insights into what the world of healthcare will look like when knowledge quality assessment mechanism for knowledge acquisition of CDSSs is fully implemented. (http://aut.researchgateway.ac.nz/handle/10292/10966)