Selected Ph.D. Thesis Abstracts

This Ph.D thesis abstracts section presents theses defended in 2019 and 2020. These submissions cover a range of research topics and themes under intelligent informatics, such as crowdsourced data, transfer learning, dynamic networks, content-based language learning, intelligent transportation systems, k-means clustering, deep learning and data mining.

COMPLEX TASK ALLOCATION FOR CROWDSOURCING IN SOCIAL NETWORK CONTEXT

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ALLOCATION of complex tasks has attracted significant attention in crowdsourcing area recently, which can be categorized into decomposition and monolithic allocations. Decomposition allocation means that each complex task will first be decomposed into a flow of simple subtasks and then the subtasks will be allocated to individual workers; monolithic allocation means that each complex task will be allocated as a whole, which includes individual-oriented and team formation-based approaches. However, those existing approaches have some problems for real crowdsourcing markets. On the other hand, workers are often connected through social networks, which can significantly facilitate crowdsourcing of complex tasks. Therefore, this thesis investigates crowdsourcing in social network context and presents models to address the typical problems in complex task allocation. The main contributions of this thesis are shown as follows.

First, traditional decomposition allocation for complex tasks has the following typical problems: 1) decomposing complex tasks into a set of subtasks requires the decomposition capability of the requesters; and 2) reliability may not be ensured when there are many malicious workers in the crowd. To this end, this thesis investigates the context- aware reliable crowdsourcing in social networks. In our approach, when a requester wishes to outsource a task, a worker candidate's self- situation and contextual-situation in the social network are considered. Complex tasks can be performed through autonomous coordination between the assigned worker and his contextual workers in the social network; thus, requesters can be exempt from decomposing complex tasks into subtasks. Moreover, the reliability of a worker is determined not only by the reputation of the worker himself but also by the reputations of the contextual workers, which can effectively address the unreliability of transient or malicious workers.

Second, traditional individual-oriented monolithic allocation for complex tasks often allocate tasks independently, which has the following typical problems: 1) the execution of one task seldom utilize the results of other tasks and the requester must pay in full for the task; and 2) many workers only undertake a very small number of tasks contemporaneously, thus the workers' skills and time may not be fully utilized. To this end, this thesis investigates the batch allocation for tasks with overlapping skill requirements. Then, two approaches are designed: layered batch allocation and core-based batch allocation. The former approach utilizes the hierarchy pattern to form all possible batches, which can achieve better performance but may require higher computational cost; the latter approach selects core tasks to form batches, which can achieve suboptimal performance with significantly reducing computational cost. If the assigned worker cannot complete a batch of tasks alone, he/she will cooperate with the contextual workers in the social network. Through the batch allocation, requesters' real payment can be discounted because the real execution cost of tasks can be reduced, and each worker's real earnings may increase because he/she can undertake more tasks contemporaneously.

Third, traditional team formation-based monolithic allocation for complex tasks has the following typical problems: 1) each team is created for only one task, which may be costly and cannot accommodate crowdsourcing markets with a large number of tasks; and 2) most existing studies form teams in a centralized manner, which may place a heavy burden on requesters. To this end, this thesis investigates the distributed team formation for a batch of tasks, in which similar tasks can be addressed in a batch to reduce computational costs and workers can self-organize through their social networks to form teams. In the presented team formation model, the requester only needs to select the first initiator worker and other team members are selected in a distributed manner, which avoids imposing all team formation computation loads on the requester. Then, two heuristic approaches are designed: one is to form a fixed team for all tasks in the batch, which has lower computational complexity; the other is to form a basic team that can be dynamically adjusted for each task in the batch, which performs better in reducing the total payments by requesters.

Fourth, current workers are often naturally organized into groups through social networks. To address such common problem, this thesis investigates a new group-oriented crowdsourcing paradigm in which the task allocation targets are naturally existing worker groups but not individual workers or artificially-formed teams as before. An assigned group often needs to coordinate with other groups in the social network contexts for performing a complex task since such natural group might not possess all of the required skills to complete the task. Therefore, a concept of contextual crowdsourcing value is presented to measure a group's capacity to complete a task by coordinating with its contextual groups, which determines the probability that the group is assigned the task;

then the task allocation algorithms, including the allocations of groups and the workers actually participating in executing the task, are designed.

In summary, this thesis develops new models to cover the shortages of previous complex task allocation works and designs efficient algorithms to solve the corresponding problems by considering the social network contexts. Experimental results conducted on real- world datasets collected from some representative crowdsourcing platforms show that the presented approaches outperform existing benchmark approaches in previous studies. The future work mainly includes designing a mechanism to identify malicious workers in the task allocation process and considering the factor of non-cooperation between workers for the complex task allocation.

Link Prediction via Transfer Learning across Multiple Domains

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THE data currently generated by modern society far exceeds our ability to analyze them manually without the help of automated analytical techniques. In this regard, the research field of knowledge discovery from data (KDD) aims at developing methods and techniques for the automatic analysis and the discovery of knowledge from data. The most important phase of the KDD process, called data mining, consists in the identification of relationships and delivers results that can be exploited both by other systems or by human experts.

In recent years, the data mining research community has spent much effort on data represented as networks, since they allow a natural description of many social, biological and information systems. In particular, individuals/objects/items are represented as nodes in the network and relationships or interactions among them are represented as links.

Among the possible mining tasks on network data, many works focused on the identification of previously unknown links among nodes. This task, which is called *link prediction*, aims to identify previously unknown links among nodes, on the basis of other known links and on the basis of the attributes/features of nodes. The link prediction task could be performed as a binary classification task when positive links (i.e. the existing links) and negative links (i.e. the non-existing links) are present. However, many real contexts are described according to the existing links among the nodes of the networks by lacking the negative links. This problem could be overcome by resorting to *transfer learning* methods.

In a classical machine learning setting, the learning is performed by considering a single target domain in order to learn a single task. Differently, in the transfer learning setting at least two domains are necessary. The goal is to exploit the knowledge of the source domain to improve the task in the target domain. Therefore, in this work three different and novel transfer learning methods are proposed which are able to fruitfully exploit the link knowledge of external and related networks in order to overcome the gap of the target network links' knowledge. Specifically, the proposed methods are able to originally combine the predictive model learned on the source network with the predictive model learned on the target network by constructing a hybrid predictive model that is more accurate to identify unknown links of the considered networks.

Experiments were performed by considering the mouse GRN as the source network and the human GRN as the target network. Quantitative and qualitative results showed that the proposed transfer learning methods are able to fruitfully exploit the knowledge acquired from the source network by outperforming state-of-the-art transfer learning methods. As a second contribution, the cross-organism importance of the organs for the network reconstruction is investigated by emphasizing that the skin and heart of the mouse are crucial to identify unknown gene regulation activities. Moreover, the proposed methods suggested gene regulations, which were not detected by other tools, that are identified as biologically relevant by experts in the biological domain.

As future work, a distributed version of the proposed methods will be developed to handle the whole set of all the possible GRNs' connections. Moreover, the methods will be enabled to work also with multiple source domains by catching the cross-domain homologies.

Pattern-based Change Detection in Large Dynamic Networks

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DYNAMIC networks are made of interconnected nodes of different types whose topology continuously evolves. In such an evolving scenario, traditional mining algorithms designed for static networks become inadequate. This is due to the concept drift problem, which manifests every time the observed data begins to diverge from the ordinary situation, thus quickly degrading the performance of previously learned models. The problem is tackled by change detection algorithms that track a quality measure of learned models to i) quickly react to drifts in data and ii) undertake the necessary actions to adjust previously learned models. However, traditional algorithms are not designed for dynamic networks, and their adaptation poses different challenges. Firstly, it is not clear what feature-set of the network to consider while performing change detection. Secondly, the notion of change is ascribed to quantitative measures, while no clear definition exists for dynamic networks since they are subject to different types of changes. Thirdly, traditional algorithms only quantify changes without characterizing them. To address these issues, this thesis proposes pattern-based change detection algorithms (PBCDs), a novel class of symbolic, unsupervised, and non-parametric change detection algorithms for simultaneously detecting and characterizing changes exhibited by large dynamic networks over the time. In particular, PBCDs search for changes on a symbolic model of the network, typically frequent patterns denoting the stable features of the network over the time discovered by pattern mining algorithms, rather than on raw data. The symbolic model is learned in an

unsupervised fashion without making any prior assumption on the data distribution.

The thesis collects different contributions concerning PBCDs. Specifically, the KARMA algorithm (networK streAm macRoscopic Microscopic chAnge) is proposed as the first PBCD algorithm adopting automatically sized time windows to seek changes as variations in the sets of frequent connected subgraphs over time. Then, KARMA is generalized into a general PBCD architecture in which to accommodate the definition of new PBCDs. Such architecture alternates the execution of a pat- tern mining step in which the symbolic model of the network is learned from incoming snapshots, a change detection step in which variations in the symbolic model are measured, and a change characterization step which characterizes the detected changes.

The architecture, implemented in an open-source framework for disseminating existing PBCDs and promoting the development of new ones, is leveraged to empirically evaluate a wide collection of PBCDs on real-world and synthetic networks. Results show that PBCDs are more accurate and efficient change detection approaches, and offer more accurate and more complete change characterizations than state-of-the-art methodologies. Moreover, the effectiveness of PBCDs in real-world applications is shown by two applications in communication network analysis and process mining, respectively. Future directions of research may concern the development of more elegant PBCDs with alternative pattern mining, change detection, and characterization steps.

AUTOMATING VOCABULARY TESTS AND ENRICHING ONLINE COURSES FOR LANGUAGE LEARNERS

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THE past decade has seen massive growth in online academic courses, most of which are offered in the English language. However, although more people speak English as their second language than as their first, online course providers do not offer language assistance. This thesis aims to remedy that by integrating domain-specific language resources into online content, taking advantage of Massive Open Online Courses for "content based language learning". Content-based language learning is the dual concept of learning a subject through a foreign language, and learning the foreign language by studying the subject. This type of content-based approach fits well with the idea of integrating language resources into existing online courses. However, doing so raises several challenges, three of which are addressed in this thesis.

First, courses teach subjects in particular domains, but supporting domain-specific language requires knowledge of specialized vocabulary. This thesis develops an automated approach to generating domain-specific corpora and wordlists, extracting domain-specific vocabulary in a way that can be applied to any online course. This has resulted in a set of automated applications that collect spoken and written content from online courses, build and annotate domain-specific corpora, and extract domain-specific wordlists based on the criteria used by the Academic Word List.

Second, acquiring and measuring language come hand-in-hand. Tools that help learners acquire new language should also include methods for testing it. This thesis takes an existing general-purpose vocabulary test – the EFL Vocabulary Test – and automates it for domain-specific language. EFL uses a combination of real and imaginary words (pseudowords) to test learners' receptive vocabulary, the automation of which has resulted in two application. The first can be used to generate domain-specific pseudowords from domain-specific wordlists, using character-grams of a specified length; while the second is used in conjunction with the first to generate domain-specific vocabulary tests.

Third, for content-based language learning to be used successfully, the language components must be smoothly integrated into courses without disturbing the original content. Moreover, our first two challenges focused on single domain-specific words, yet vocabulary support should include not just single words, but also multi-word lexical items such as collocations and lexical bundles. The culmination of the work in this thesis has resulted in the creation of F-Lingo, a Chrome extension that works on top of FutureLearn MOOCs to provide online learners with language resources for domain-specific words, phrases (collocations and lexical bundles), and concepts. It is completely automated, though would also lend itself to selective teacher intervention.

Finally, a learner-based evaluation has been conducted, where 109 participants were tracked using the F-Lingo Chrome extension. This evaluation provided insight into the way in which learners interact with F-Lingo, showing, for example, that they spend more time looking at additional lexical information for concepts than they do for words or phrases. The next step would be to conduct an extensive longitudinal study, measuring learner's vocabulary before, during, and after using the Chrome extension, in turn measuring the effectiveness of F-Lingo as a language resource or for language acquisition. (https://researchcommons.waikato.ac.nz/handle/10289/12929)

DEVELOPING NEW TECHNIQUES TO IMPROVE LICENCE PLATE DETECTION SYSTEMS FOR COMPLICATED AND LOW QUALITY VEHICLE IMAGES

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INTELLIGENT transportation systems (ITSs) play a very important role in people's lives in many respects. One of the most important ITS applications is for automatic number plate recognition systems. Over the years, many algorithms have been developed for detecting licence plates (LPs) from vehicle images or from a sequence of images in a video. Many existing ITSs work only under good conditions or normal environments.

It is still challenging to find effective techniques to identify LPs under difficult conditions, such as low/high contrast, bad illumination, foggy, dusty, or distorted by high speed or bad

weather. New techniques are needed to improve the performance of existing detection systems. The main contributions of this research as follows:

1) Effective methods were developed for detecting LPs under complicated conditions, such as low/high contrast, bad illumination, foggy, dusty, and distorted by high speed and bad weather. They improved the detection system performance with less execution time and a low false-positive rate.
2) Presenting new preprocessing and extraction techniques that can improve the classification accuracy.
3) Investigating which method is better to achieve the main requirements of an LPD system under difficult conditions.

The research significance is that the proposed methods can improve the performance of the existing ANPR systems under complicated conditions. In addition, the outcomes will contribute to increasing the quality of transport systems with better efficiency and safety.

The motivation of this research is to select good software components for detecting complicated LP problems. Those components play an important role in the quality of the LPD system. Therefore, the preprocessing and feature extraction techniques should be selected and developed carefully to improve system weaknesses.

In this thesis, novel methods are developed for licence plate detection (LPD) systems to extract key features, and classify the LP region from complicated vehicle images based on preprocessing methods and machine learning algorithms with several types of texture descriptors.

In order to identify LPs from complicated vehicles images, four LPD methods were developed in this research. The first, is a three-level local binary pattern operator based on an ensemble of Adaboost cascades classifiers. The second method, introduces a new texture descriptor based on a multi-level preprocessing stage with extended local binary pattern descriptor using an extreme learning machine classifier. The third, develops learning-based preprocessing methods using a local binary pattern and a median filter histogram of the oriented gradient with support vector machine classifier for detecting complicated LPs. Finally, for identifying distorted LPs using hybird features, median robust extended local binary pattern and speeded-up robust with an extreme learning machine classifier. The experimental results show that both of the third and fourth algorithms perform very well in LP detection accuracy rate compared with first and second algorithms. Also, the false positive rate (FPR) for both methods is better than those algorithms. The second and fourth methods carry out significant classification of different types of LP key features. The first approach takes much less execution time and produces high FPR compared to the three other methods. But it was a good technique for selecting suitable preprocessing and extraction methods, for detecting LPs from low quality vehicleimages.

The experimental results proved the efficiency of the proposed approaches for detecting difficult regions of the LP inside a vehicle image. The findings suggest that the outcomes of this study can improve the performances of existing LPD systems. They can assist in law enforcement with an ITS system. Also, it can be effectively used to detect LPs in real-time applications under difficult conditions. Method 1: The overall performance evaluation for detection, precision, and F-measure rates are 98.56%, 95.9%, and 97.19%, respectively, with an FPR of 5.6%. The average detection time for the whole system per vehicle image was 2.001ms. Method 2: The detection accuracy and FPR compare with Method 1 were improved by 0.54% and 0.56%, respectively. The classification and detection rates are 99.78% and 99.10%, respectively, with an FPR of 5%. The average execution time for the whole detection system per vehicle image was 2.4530ms. Method 3: This method yielded an excellent improvement over existing methods, a 4% improvement for the FPR, and 1.50% for accuracy with execution time. The overall performance evaluation for the object localization metrics of the detection or recall rate is 99.62%, with an FPR of 1.675%. The average of the runtime for the whole detection system per vehicle image was 2.2187ms. Method 4: The accuracy and detection rates are 97.92% and 99.71, respectively, with the FPR of 2.24%. The average runtime for the whole detection system per vehicle image was 2.108 ms. The method was superior in the performance and execution time over the existing proposed methods in this research.

The future work will investigate the possibility of using those methods to improve ANPR applications. To facilitate the further development of this work, a few key areas below have been explored.

Concerning the first and second algorithms, they can be improved to further reduce the false positive rate and extraction time using the preprocessing techniques.

One future improvement could be to eliminate those LP objects that look like the LP and have the same characteristics as LP regions, such as texts or commercial signs and logo objects. This step would decrease the processing time as well as the memory required to process the LP detection task.

In addition, using a combination of several supervised machine learning algorithms instead of a single one is very efficient. This is a preferable solution for capturing more information about the LP area and increase the detection system and classification accuracies. Those methods can be applied to different types of LP datasets, such as Australian car LPs, Arabic car LPs, and so on. More generally the proposed methods could be used by other fields that are related to objects detection subjects. Due to using supervised learning techniques, there is no limitation in those methods which are associated with objects shape, color, and edge and so on.

Further study is required to take account of other challenges and to enhance this work for dealing with other difficult conditions, such as licence plates with difficult tilt, rain, and snow in images. The detected LPs are normally stored as images in the memory and used by transportation systems to complete their tasks. This needs more storage devices, therefore, the LP recognition stage is required. This stage works to recognize the LP number as a text using deep learning algorithms and template matching techniques with optical character recognition (OCR).

This thesis studied offline detection methods, but it is

desirable for this work to be applied to real online LPD systems to see the impact of this research. This will require more work. Therefore, all of the proposed methods need to be employed for online detection. This would be a significant achievement in the field of transport systems for work under difficult conditions.

IMPROVED K-MEANS CLUSTERING ALGORITHMS

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K-MEANS clustering algorithm is designed to divide the data points into subsets with the goal that maximizes the intra-subset similarity and inter-subset dissimilarity where the similarity measures the relationship between two data points. As one of the most popular and widely used unsupervised machine learning techniques, K-means clustering algorithm has been applied in a variety of areas such as artificial intelligence, data mining, biology, psychology, marketing, medicine, etc.

The result of K-means clustering algorithm depends on the initialization, the similarity measure, and the predefined cluster number. Previous research focused on solving a part of these issues but has not focused on solving them in a unified framework. However, fixing one of these issues does not guarantee the best performance, so that it is significant to conduct further research to improve it. This thesis conducts an extensive research on K-means clustering algorithm aiming to solve the issues of the initialization, the similarity measure, and the determination of cluster number simultaneously.

First, the Initialization-Similarity (IS) clustering algorithm is developed to solve the issues of the initialization and the similarity measure of K-means clustering algorithm in a unified way. Specifically, the initialization of the clustering is fixed by using sum-of-norms (SON) which outputs the new representation of the original dataset and the similarity matrix is learnt based on the data distribution. Furthermore, the derived new representation is used to conduct K-means clustering.

Second, a Joint Feature Selection with Dynamic Spectral (FSDS) clustering algorithm is developed to solve the issues of the cluster number determination, the similarity measure, and the robustness of the clustering by selecting effective features and reducing the influence of outliers simultaneously. Specifically, the similarity matrix is learnt based on the data distribution as well as adding the ranked constraint on the Laplacian matrix of the learned similarity matrix to automatically output the cluster number. Furthermore, the L2,1-norm is employed as the sparse constraints on the regularization term and the loss function to remove the redundant features and reduce the influence of outliers respectively.

Third, a Joint Robust Multi-view (JRM) spectral clustering algorithm is developed. JRM considers information from all views of a multi-view dataset to conduct clustering while solving initialization, similarity measure, cluster number determination, feature selection, and outlier reduction issues for multi-view data in a unified way. Extensive experiments have been carried out to evaluate the performance of all the proposed algorithms on real-world data sets from UCI machine learning repository. The results obtained and presented in the thesis show that the proposed algorithms outperformed the state-of-the-art comparison clustering algorithms. More specifically, the proposed IS clustering algorithm increased average ACC by 6.4% and 3.5% compared to K-means and Spectral clustering algorithm on data sets Digital, MSRA, Segment, Solar, USPS, USPST, Waveform, Wine, Wireless, and Yale. The proposed FSDS clustering algorithm increased average ACC by 12.56%, 4.43%, 5.79%, and 11.68% respectively compared to K-means clustering algorithm, spectral clustering algorithm, clustering with adaptive neighbors algorithm, and robust continuous clustering algorithm on datasets Cardiotocography, Diabetic Retinopathy, Parkinson Speech, German Credit, Australian Credit Approval, Balance Scale, Credit Approval, and Musk. The proposed JRM algorithm increased average ACC by 41.95%, 33.49%, 40.01%, 34.38%, and 39.32% respectively, compared to best K-means clustering, concatenation-based K-means clustering, graph-based system algorithm, adaptively weighted Procrustes algorithm, and multi-view low-rank sparse subspace clustering algorithm on datasets 3Source, Washington, Flowers, Texas, Wisconsin, and Cornell.

The proposed clustering algorithms in this thesis solve the determination of the cluster number K, initialization, similarity measure and robustness issues of K-means clustering algorithm in a unified way. In addition, the convergences of the proposed optimization methods for the proposed objective functions are theoretically proved. The proposed algorithms can be used in a wide range of applications such as customer behavioral segmentation, anomalies detection, cyber security, sensor measurements sorting, inventory categorization, etc.

CONTRIBUTION TO THE DEVELOPMENT OF ALGORITHMS BASED DEEP LEARNING ARCHITECTURES FOR MOBILE ROBOTIC'S APPLICATIONS

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MOBILE robotic encounters many problems as robots move into dynamic environments. Particularly, the large amount of variety faced in real-world environments is extremely difficult for existing robotic applications to handle. This requires the use of machine learning methods, which can learn models for each task. Most of these methods require significant hand-designed representations to learn classification models. However, designing good features is crucial to the success of a machine learning algorithm for a specific problem, such features are often unintuitive and need considerable effort to design.

Recently, deep learning can solve these problems by learning features directly from data without any human intervention. In such architectures, the inference consists of a series of matrix multiplications to weight inputs followed by element-wise non-linear operations, and thus justify that the inference does not require optimization. Due to these advantages, we

propose different approaches in the context of mobile robotic applications using the existing deep learning methods.

This dissertation presents a direct application of deep learning in different mobile robotic tasks including object and scene classification as well as topological navigation and is encompassed in three major parts. In the object classification part, we propose several approaches using 2D/3D descriptors and Deep Belief Network (DBN). In the first contribution, we propose many local and global approaches for classifying both 2D and 3D objects using 2D/3D Bag of Words as well as our new global descriptor Viewpoint Features Histogram- Color (VFH-Color). VFH-Color combines both the color information and the geometric features extracted from the previous version of Viewpoint Features Histogram (VFH). In the second contribution, we extract geometric features from the segmented 3D point clouds using the VFH descriptor and then we learn these features with both generative and discriminative DBNs to evaluate their performance in the context of 3D object categorization.

The second part tackles the scene classification including two main contributions. The first one is centered on biologically inspired methods for representation and classification of indoor environments. It combines gist features and discriminative DBN, which showed previously its performance in object classification. The second contribution provides a new multimodal feature fusion for robust RGBD indoor scene classification. This approach consists of two separate Convolution Neural Networks (CNNs) trained on RGB and depth images, then combined with a late fusion network.

The last part presents our contributions in the topological navigation field. First, we propose a new method of exploring indoor environments by an autonomous mobile robot, as well as building topological maps. In this contribution, we define a new topological map building concept using global visual attributes that are extracted from omnidirectional images. Second, we extend our previous work by using Convolution Long Short-Term Memory (C-LSTM) to perform scene recognition-based topological mapping and localization. The C-LSTM involves CNN layers to extract features from the input data combined with LSTM to consider the information of the previous frames, thus learning the temporal dependencies of the robot movement.

The results obtained during this thesis are globally very promoting and encouraging. However, we focus on the limitation of some approaches and the problems encountered throughout these works, and, at the same time, the possible solutions to overcome them. Training deep neural networks with large datasets requires an increasing amount of computation resources. This might take from hours to weeks depending on the dataset, the computational power, and the algorithms being used for the training. However, the common limitation of all our approaches depends on the hardware used to learn our data. In our experiments, we used only the CPU device because of the limited graphic memory of our GPU card. Therefore, we fixed a limited number of epochs and the small size of image datasets, which may influence the obtained results. In future work, we will implement our approaches on the GPU card to be massively parallelized and thus sped up.

Since our 2D/3D object classification approaches in the first part showed good results compared with the state-of-the-art, we will extend our work to object grasping which constitutes an essential component in an autonomous robotic manipulation system operating in human environments.

In the second part, we will exploit the object classification results to perform indoor scene recognition through the objects present in the scene. We will assign a probability to each object class, then count all the object probabilities to predict the scene class. In this way, the object and scene classification will be two dependent tasks that can be used in mobile robotic navigation.

In the last part, we will propose a semantic navigation approach based on the sequence to sequence learning. Such an approach will provide high-level communication between robots and humans. Besides omnidirectional and RGB images, in the next work, we will integrate depth information to perform navigation with RGBD sensors.

Data Mining for Personalised Clinical Decision Support Systems

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With the addition of new drugs in the market each year, the number of drugs in drug databases is constantly expanding, posing a problem when prescribing medications for patients, especially elderly patients with multiple chronic diseases who often take a large variety of medications. Besides the issue of polypharmacy, the need to handle the rapid increase in the volume and variety of drugs and the associated information exert further pressure on the healthcare professional to make the right decision at point-of-care. Hence, a robust decision support system will enable users of such systems to make decisions on drug prescription quickly and accurately.

Although there are many systems which predict drug interactions, they are not customised to the medical profile of the patient. The work in this study considers the drugs that the patient is taking and the drugs that the patient is allergic to before deciding if a specific drug is safe to be prescribed. To exploit the vast amount of biomedical corpus available, the system uses data mining methods to evaluate the likelihood of a drug interaction of a drug pair based on the textual description that describes the drug pair. These methods lie within the prediction layer of the conceptual three-layer framework proposed in the thesis. The other two layers are the knowledge layer and the presentation layer. The knowledge layer comprises information on drug properties from drug databases such as DrugBank. The presentation layer presents the results via a user-friendly interface. This layer also obtains information from the user the drug to be prescribed and the medical profile of patients. Models used in these data mining methods include the network approach and the word embedding approach. A survey conducted on dentists found positive response in the use of such a system in helping them in drug prescription which result in a better treatment outcome.

One possible extension to the current work include the leveraging of Semantic Web technology with alternative data repositories such as PubMed and compare the results to evaluate if it is more efficient. Performance of the experiment can also be further evaluated by having the models amalgamated to form an ensemble model. The research has made the novel discovery that drug interactions are associated with similarities derived from their feature vectors. Similarity ratio of a drug-pair can be obtained from the paths that link the common drugs within the set of interacting drugs of the respective drug-pair. This results in a significant contribution relating to the design of personalised clinical decision support systems for use in healthcare institutions, transforming the clinical workflow at point-of-care within the healthcare domain.