INTEGRATING AGENTS WITH CONNECTIONIST SYSTEMS TO EXTRACT NEGOTIATION ROUTINES

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Abstract: Routinization is a technique of knowledge exploitation based on the repetition of acts. When applied to negotiations it results the substitution of parts or even whole processes, disembarrassing negotiators from significant deliberation and decision making effort. Although it has an important impact on negotiators, the risk of establishing ineffective routines is evident. In our paper we discuss weaknesses and limitations and we propose a generic framework to address them. We consider routines as evolving processes and we take two orientations. The first concerns a communicative dimension to allow for external evaluation of the applied routines and the second concerns enforcement of the system core with evolving structure that adjusts to routine changes and flexibly incorporates new knowledge.

1 INTRODUCTION

Organizations mostly engage in improvement strategies that concern knowledge exploitation and exploration. Exploitation is considered similar to recalling past experience to deal with current issues, while exploration is considered similar to adopting imitative or innovative tactics in the search for new knowledge. Several techniques have been developed to support exploitation and involve knowledge refinement, routinization and elaboration of existing ideas, paradigms, technologies, processes, strategies and knowledge. Exploration, on the other hand, is mostly supported through experimentation with new ideas, paradigms, technologies, processes, strategies and knowledge that improve on old ones. As depicted in (Dyba, 2000) the basic balance problem is “to undertake enough exploitation to ensure short term results and concurrency to engage in exploration to ensure long term survival”. Our study mainly focuses on routinization as a means of knowledge exploitation and its employment in negotiations. Negotiation routines are understood as repetitive acts in several stages of the negotiation process. The identification of the context that enables routine development and routine ‘subconscious’ retrieval, result to the development of more effective negotiators who accomplish the same outcomes with the minimum deliberation effort. Nevertheless several limitations have been acknowledged. Efficiency decrease that arises from inflexibility and rigidity produced by routine establishment, as well as lack of formal theoretical frameworks and theories to routine application in negotiations are among the most important impediments. Furthermore routines should be viewed as evolving processes, since the repetitive acts may change over time even under similar negotiation contexts, and distinct AI techniques are not adequate to support such processes. In sections 2 and 3 we give a brief definition and background of routines and their development in several negotiation stages, as well as an analysis of theoretical weaknesses and shortcomings of routine establishment. In section 4 we identify the features that a system acquiring and extracting negotiation routines should be enhanced with, and we propose a generic framework for such a purpose. In section 5 we explain how the proposal is expected to address the discussed limitations and appose future research issues.

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2 ROUTINES FOR KNOWLEDGE EXPLOITATION

"Routines" is the general term used for the definition of all regular and predictable behavioral patterns (Nelson, Winter, 1982). Although there is no final agreement on an exact definition, researchers indent that repetition of acts is a necessary precondition for the acquisition and application of routines (Kesting, 2007). When an agent executes an act for the first time, it faces the challenge of identifying and evaluating alternatives that will lead to an intended state. It is given the opportunity to observe the results of the initial solution and if it is effective, it can be applied to similar problems. The substance of routines is the specific knowledge acquired by the repeated planning and execution of an act combined with the ability to apply this knowledge to specific situations. It has the potential to substitute deliberate planning and decision making since it is used to determine what operations to conduct in order to realize certain intended state. Routinization forces agents to develop 'best practices'.

2.1 Development of Routines in Negotiation

Negotiation is most commonly defined as the search for an agreement that satisfies the requirements of two or more parties. Several scientific fields have made contributions to the development of negotiation theory. (Gulliver 1979, Robinson & Volkov 1998, Putnam & Roloff 1992) discuss negotiation models that follow normative, prescriptive or descriptive approaches derived from the application of economic theories, management and social sciences respectively. Although theoretical perspectives and definitions may vary, there is a general consensus regarding the number of stages in the negotiation process. Most approaches model negotiation in three basic stages: (a) prenegotiation stage basically concerned with strategy formulation, commitment to rules, observation of the other party behavior, definition of issues and problem formulation (b) negotiation dance, which is mainly concerned with the exchange of offers and counter-offers and (c) execution of negotiation results. Negotiations may be fully or semi-automated processes and systems that facilitate the decision making in several stages have been developed. Nevertheless, the application of routines in negotiation has not been extensively studied (Kesting, Smolinski, 2007). In what context are similar negotiation cases identified? How can negotiation data (about products, shipping info, particulars of buyers and sellers, orders and dialogues of negotiation) be used to extract knowledge which will be reused in further negotiations? (Kesting, Smolinski, 2007) Introduces a theoretical framework which identifies different negotiation situations where routine can develop, based on similarity and stability of negotiation elements measured in two dimensions. The problem-solving (substance of negotiation) dimension and the communication dimension, concerning negotiation partners. The framework in (Kesting, Smolinski, 2007) concludes that negotiation success is based on a combination of problem-solving/analytic and negotiation/communication skills that negotiators possess, with routine application. Routine has an important impact on negotiations, since it allows negotiators to develop their capabilities, improve their efficiency and save scarce planning capacities and time by employing automated procedures.

3 PROBLEM STATEMENT

A commonly stated risk posed by routinization is the application of ineffective acts. As stated in (Nelson & Winter 1982, Winter 1986, Cohendet & Llerena 2003) with increasing repetitions, decision making prior to the operation tends to decrease. The use of routines entails rigidity and once a solution is established, it is not further questioned. As a result, formal routines alone are inadequate and might demand improvisational skills. (Kesting, 2007) Investigates the mechanisms that tend to make routines resistant to change and are the major source for inflexibility. The first concerns stability of intention. Routines are developed to bring about a specific intended state and as a consequence intention defines a narrow frame that restricts the extent of possible changes. The second mechanism is derived from repetition which is prerequisite for the application of routines. Repetition transcends planning efforts, therefore routines are stable and do not change. The third mechanism that is recognized concerns automation. With increasing repetitions the course of an act is automated, without further deliberation.

The application of routines in negotiation has not been researched, and the lack of formal models describing the context and conditions that favor their development is an obvious impediment. How the negotiation environment is formally represented and how is similarity of distinct contexts measured? To overcome this theoretical limitation we make the generic assumption that negotiation context can be represented as a vector in n_1 dimensional space (input space X), and similarity of distinct contexts is calculated through distance vectors. Furthermore, we assume that routines can be represented as vectors in n_2 dimensional space (output space Y) and any framework that results to routine extraction must provide mappings from the input space X to the output space Y.

Another important issue we need to address concerns the decision of the most appropriate technique that will provide mappings from input to output space, as long as the development of a model with a dynamic structure in order to accommodate new knowledge and produce new routines in a flexible and adaptive manner. Routinization must be viewed as an evolving process, since the negotiation context may change over time resulting to different outcomes. A necessary first step is the study of existing systems that exploit previous knowledge in order to provide advising services during the various phases of the negotiation process. A categorization of such systems is provided in (Braun, Brzostowski et al., 2005) and several AI methods and techniques have been successfully developed and used. Nevertheless a number of problems, which are discussed in (Kasabov, 2007), arise from the application of such techniques to evolving processes:

1. "Difficulty in preselecting the system's architecture: Computational Intelligence models usually retain a fixed architecture (e.g. number of neurons and connections)". This restricts us to a view of a close problem space (fixed input and output space), which is not the case if we consider that negotiation environment and routines may change over time.
2. "Catastrophic forgetting: Systems usually forget a significant amount of old knowledge while learning from new data." This fact prohibits the development of a framework that balances knowledge exploitation with exploration.
3. "Excessive training time required: Training usually requires many iterations of data propagation through an ANN structure." If knowledge insertion and routine extraction is time consuming the model is not considered efficient.
4. "Lack of knowledge representation facilities: Existing Computational Intelligence architectures capture statistical parameters during training, but do not facilitate the extraction of evolving rules in terms of linguistically meaningful information." If knowledge is represented in terms of IF-THEN rules (eg. If <context> then <routine>) in order to be linguistically meaningful, we can consider the exchange of locutions between agents in terms of exchange of experience.

4 PROPOSAL

The main problem posed by routinization is the risk of acquiring and applying ineffective routines. To this extent, we trust that the system producing routines should be enhanced with learning capabilities in order to evolve according to possible satisfaction or dissatisfaction measures caused by the applied routines. Furthermore it should be enhanced with communicative abilities in order to interact with the agents that apply the routines.

The underlying framework should combine knowledge exploitation and knowledge exploration techniques, and should have an evolving structure in order to adapt to environmental changes. We outline several desirable characteristics of an evolving model that exploits and explores negotiation knowledge.

1. Previous knowledge can be modeled in pairs of data (x,y), where the desired output vector y is known for an input vector x. In order to associate data from the input space X to the output space Y, the system must be enriched with supervised learning abilities.
2. The system must interact with negotiators, in order to trace dissatisfaction caused by the application of a routine, request additional planning and decision making and allow the insertion of new knowledge to the system. External evaluation by the negotiators results in breaking the rigidity of routines. This feature demands the development of a communication protocol between the system and the negotiators, as well as an adaptive structure to allow for efficient knowledge insertion.
3. The system must be able to adapt to new data of unknown distribution. We must take into account that it may develop in its own machine learning space M, different from the original data space Z. New data vectors may have more or fewer dimensions, resulting to dimensionality change of the problem space over time. Therefore we consider an open problem space.

4. System adaptation must be fast and not require many iterations.

We propose a model that consolidates the above characteristics and stems from the integration of an intelligent agent and an Evolving Connectionist System (ECOS). "An ECOS is an adaptive, incremental learning and knowledge representation system that evolves its structure and functionality, where in the core of the system is a connectionist architecture that consists of neurons and connections between them" (Kasabov, 2007). We outline the learning abilities of ECOS that position them as top candidates for the combination of knowledge exploitation and exploration.

1. "ECOS may evolve in open space, where the dimensions of the space can change"
2. "They learn via incremental learning, possibly in an online mode"
3. "They may learn continuously in a lifelong learning mode"
4. "They learn both as individual systems and as evolutionary populations of such systems"
5. "They use constructive learning and have evolving structures"
6. "They learn and partition the problem space locally, thus allowing for a fast adaptation and tracing the evolving processes over time"
7. "They evolve different types of knowledge representation from data, mostly a combination of memory-based, statistical and symbolic knowledge".

A simple ECOS system is eMLP (Kasabov, 2007), which is a three-layer network with two layers of connections. The first consists of input variables, which represent the negotiation context. The second contains rule nodes that evolve and allow for layer growth during training. The rule nodes represent the mapping of input to output space. These mappings may be considered as IF-THEN rules, IF <negotiation context> THEN <routine>.
The similarity of input vectors, which is a precondition to routine application, is calculated through the normalized distance between the input vector and the incoming weight vector of the rule node. Activation for the rule node is given through A = 1 – Distance, which indicates that the more similar the input vector (current negotiation context) is to a previous case, activation tends to 1. A sensitivity threshold may be used for the definition of similarity. Supervised learning is also applied, and the normalized output error is calculated. The third layer represents the values of the output variables, constituting the routines. The model structure facilitates the accommodation of new training examples within the evolving layer either by modifying connection weights or by adding new nodes. eMLP is suitable for online output space expansion, because it tunes only the connection weights of the local node and does not require retraining of the whole system as in traditional neural networks. In order to add a new node to the output layer, the structure of the eMLP need to be modified to accommodate the output node. The modification affects only the output layer and its connections with the evolving layer. As a result of the training process new nodes will be added to the evolving layer to represent new input-output associations. The architecture of eMLP is illustrated in figure 1, indicating the growing structure of the evolving and output layer.

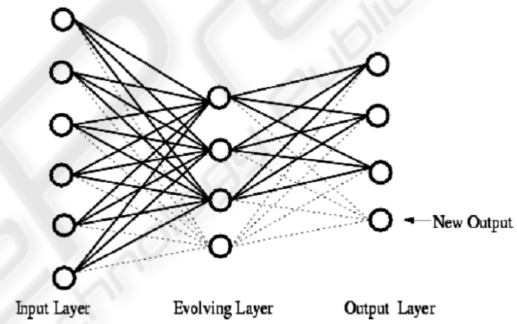

Figure 1: The evolving structure of eMLP (reproduced with permission).

In order to meet all of the desirable characteristics described above, the system must be enriched with the ability to communicate with the negotiators and receive external utility measurement or even be provided with new information, evolving the established routines. Our suggestion concerns the integration of the eMLP with an intelligent agent, which will act as a mediator providing negotiation routines to the negotiator. The mediator will collect previous negotiation knowledge from the negotiator and train the eMLP which will be the agent core. The communication protocol will support requests for routine acquisition generated by the negotiator, and routine proposals by the mediator. After the application of each routine, the negotiator will proceed to evaluation (by using a utility function) and in case of dissatisfaction, the routine will break and the negotiator will be challenged to apply his skills for knowledge exploration. The new knowledge will be provided back to the mediator and result to the evolution of the eMLP.

5 EXPECTED RESULTS

Our research attempts to shed light to the field of negotiation optimization, by focusing on the acquisition and application of negotiation routines.

It is commonly stated that the main problem of routinization is the risk of applying ineffective routines. As discussed earlier, among the causes that produce inflexible routines lays a repetitive mechanism that prohibits further questioning or evaluation of the acts. We trust that our framework makes contribution to theory of negotiation routines by presenting two essential directions for breaking routine rigidity. The first concerns the identification of the need of external evaluation after each routine has been applied and the second concerns the enrichment of the system core with an evolving structure that adjusts its functionality to accommodate new knowledge. The first direction actually indicates the necessity to keep an open communication channel with the environment, and allow for the notification and triggering of routine change. The second direction concerns the identification of an appropriate structure that embraces evolving processes, in order to absorb new knowledge and proceed to routine change.

To this extent we have outlined four desirable characteristics in section 4 that are met in our proposed framework. The first concerns a hypothesis of the representation of negotiation context and routines as vector pairs. The second identifies the need of external routine evaluation and dynamic system structure. Our framework suggests the integration of the dynamic system structure (ECOS) with a negotiation agent, in order to allow the interaction of the model that captures knowledge and extracts routines with the negotiators, and be notified in terms of a utility measure (after routine application). The mediator agent will be motivated, if the utility decreases, to request further planning by the negotiators. The results (new knowledge) will then be inserted to the dynamic structure. The third and fourth characteristics concern the system's ability to develop in open space and quickly adapt to the environment. These characteristics are met by the ECOS structure, since it learns and partitions the problem space locally. Furthermore in section 3 we have identified several limitations posed by the application of AI techniques in evolving processes. These are addressed by ECOS algorithms, since they apply fast one-pass learning (adaptation) and are resistant to catastrophic forgetting (Kasabov, 2007). Their structure is simple and grows in terms of adaptation to the environment (the eMLP grows by the addition of new nodes to the evolving and output layer). Finally ECOS systems evolve different types of knowledge representation from data; therefore our representational hypothesis is not limited.

This framework is completely new and will be tested in several stages of negotiation to provide support to negotiators by the extraction of routines. We trust that since the system is evolving it will lead to efficient results in prenegotiation processes (strategy formulation, commitment to rules, opponent observation, issues and problem formulation, other prenegotiation convensions), as well as in negotiation processes (decision of proposal and negotiation locutions). We have made the hypothesis that knowledge can be provided to the system in pairs of x, y vectors therefore the model is generic and can be used for the substitution of parts or even whole negotiations. Our future research concerns extensive tracing of negotiation repetitive acts, and the development and application of our model in those that can be modeled as vector pairs. If in several cases uncertainty is introduced to vector dimensions and we need to address the issue of missing values, the framework can be extended to contain evolving fuzzy neural network (EFuNN) instead of simple eMPL in its dynamic structure. EFuNNs, function as eMLPs but have two extra connection layers that represent fuzzy input and output spaces. For these cases we will investigate the integration of EFuNNs to our mediator framework. Model validation, in terms of the generalization ability of the ECOS core to produce good results on new, unseen data samples, can be implemented by splitting the original dataset to train and test sets and calculating the actual error of the system. The most commonly stated validation methods are simple train and test split of data, k-fold cross validation and leave-one-out cross validation. Furthermore, the proposed structure itself suggests external evaluation of the applied routines by the negotiators, which contributes in measuring the overall system performance.

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