Hybrid BDI Agents with ANFIS in identifying Goal Success Factor in a Container Terminal Application

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Abstract

Faster turnaround time of vessels and high berth productivity are paramount important factors of any container terminals in assuring competitive advantage in the shipping industry. The Paper proposes a hybrid BDI agent model with Neural Networks and Adaptive Neuro-fuzzy Inference system (ANFIS) in dealing with complex environments such as operations in container terminal in the shipping industry. Hybrid model is emphasized to improve the learning capabilities of the generic BDI agents. A plan Tuple: PLAN < B, D, I, SF, TY> is introduced in handling plans in the intention structure where, B - Beliefs, D - Desires, I - intentions, ST - success factor and TY for the type of the plan. Learning capabilities and handling partially successful goal states in the BDI agent model have been improved with the introduction of the hybrid architecture suggested.

2: Hybrid BDI Agent Architecture in Berthing System

Tasks involving in berths, vessels and scheduling are being proposed to handle by three different types of agents namely, VESSEL-AGENT (VA), SCHEDULE AGENT (SA) and BERTH-AGENT (BA). Main agents in the system are shown in figure 1.

Figure 1. Main agents in the proposed system

Hybrid BDI architecture proposed for the SA is described in the next section of the paper giving detail description of how learning and adaptability are experienced in the proposed architecture.

3: Proposed Hybrid Architecture for the Schedule-Agent
Two important modules have been suggested in the hybrid BDI agent model namely “Generic BDI module (GBM)” and the “Knowledge Acquisition module (KAM)” as shown in figure 2.

![Figure 2. Hybrid BDI Agent Architecture](image)

4: Component in the Proposed Hybrid BDI model for SCHEDULE-AGENT.

The main components of the Schedule-Agent are Event-Handler, Plan-Selector, Plan-executor, and Goal-Evaluator. The different component in the Schedule-Agent will assure the execution of the abstract BDI execution cycle, dynamic nature in selecting appropriate plans in the intention structure and very importantly, learning and adaptability features. Average success factor ($\bar{\lambda}$) of all plans is given as: 

$$\bar{\lambda} = \frac{1}{n} \sum_{i=1}^{n} (\mu_i)$$

where $\mu_i$ denotes the success factor of $i^{th}$ plan in the intention structure.

5: A Test Case

A berthing scenario at JCT, port of Colombo has been simulated with the proposed hybrid BDI agent model. JCT has four container berths namely JCT1, JCT2, JCT3 and JCT4. Expected time of completion of the cargo operations in berth JCT2 and JCT3 and other values computed by the Plan-Executor are shown in table 1.

<table>
<thead>
<tr>
<th></th>
<th>ETC\text{old}</th>
<th>EVP\text{zim}</th>
<th>EOT\text{zim}</th>
<th>ETC\text{zim}</th>
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<td>Sun 0436</td>
</tr>
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<td>JCT3</td>
<td>Sat0435</td>
<td>48.3</td>
<td>20.0hrs</td>
<td>Sun 0147</td>
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| **Table 1. ETC\text{new} in berth 2 and 3** |

ETC\text{zim} is the expected time of completion of the current vessel in berth $i$, EVP\text{zim} denotes the expected vessel productivity and EOT\text{zim} denotes the expected time of operations for the vessel $zim$ in berth $i$. JCT3 berth has been chosen from Plan-Selector component as it indicates the earliest expected time of completion (ETC).

Membership functions created from the ANFIS for SF is shown in figure 3(a) and Figure 3(b) shows one of the decision surface produced for the rules learnt by ANFIS for inputs SF of the plans. ANFIS model proposed in the Goal-Evaluator component has indicated that the average success factor of completing the cargo operations of the vessel ZIMJ is only 64% in JCT3. In this particular example, Hybrid BDI agents in the container terminal have indicated that this operation might not be able to complete as expected.

![Figure 3(a): Membership Function of SF](image)

![Figure 3(b): Decision Surface](image)

6: Conclusion

Knowledge Acquisition Module (KAM) proposed in the hybrid BDI model has shown remarkable improvement in the behavior of generic BDI model in a complex environment. In particular, the adaptive learning behaviors included in neural networks and ANFIS indicated that this is a promising approach to build adaptive hybrid intelligent agents who can quite easily deal with any type of beliefs and desires in selecting appropriate plans for the intention structure, finally predicting the degree of the success factor of the final goal. Efficiency of the operations at container terminals could be guaranteed as intelligent agents could suggest various delays or difficulties expected in advance to the terminals management.

References

url : http://www.citeseer.nj.nec.com/rao95bdi.html

