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Highway Entrance Ramp Monitoring and Control using Soft Computing Techniques

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***ABSTRACT:* - Highway entrance ramp monitoring and control is used to regularize the flow of traffic entering through the highway entrance ramps. It detects the flow of traffic entering through the highway ramp monitoring system and controls the flow of traffic using ramp monitoring and control algorithm. This algorithm employs some soft computing techniques which is a suitable choice due to the imprecise information and the level of inaccuracy in the monitoring data available.**

The use of AI-based search algorithms to calibrate the parameters of a micro-simulation model or estimate the dynamic demand needed to run the model is an area that has received significant attention from researchers recently. Use of soft computing techniques improves the traffic flow as also increases the efficiency of the traffic system with enhanced control and safety.

***Keywords:* - Soft Computing, Traffic Monitoring, Traffic Control, Agent-Based Algorithms, Transportation**

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1. HIGHWAY RAMP MONITORING

The objective is to find the optimal solution that minimizes the minimizes the cost for maintaining and operating the highway monitoring system employing some soft computing techniques which can be further extended in numbers and area of use. These techniques make them an appropriate choice for use in this kind of problems which is complex as well as showing a varying degree in predicting the behavior of the traffic on highway. As a ramp is the entrance and exit points on the highways those can be monitored and controlled using traffic signals.

2. SOFT COMPUTING

Soft Computing is term used in computer science to refer the problem in computer science whose solution is not predictable, uncertain and between 0 and 1. Soft Computing became a formal Computer Science area of study in early 1990s. [6]

"Basically, soft computing is not a homogeneous body of concepts and techniques. Rather, it is a partnership of distinct methods that in one way or another conform to its guiding principle. At this juncture, the dominant aim of soft computing is to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness and low solutions cost. The principal constituents of soft computing are fuzzy logic, neurocomputing, and probabilistic reasoning, with the latter subsuming genetic algorithms, belief networks, chaotic systems, and parts of learning theory. In the partnership of fuzzy logic, neurocomputing, and probabilistic reasoning, fuzzy logic is mainly concerned with imprecision and approximate reasoning; neurocomputing with learning and curve-fitting; and probabilistic reasoning with uncertainty and belief propagation" [5].

2.1 Agent-Based Algorithms

Agents have behaviors, often described by simple rules, and rules to change their behavior. By modeling agents individually, the full effects of the diversity that exists among agents in their attributes and behaviors can be observed as it gives rise to the behavior of the system as a whole. By modeling systems from the ground up (agent by agent), self organization and system evolution can often be observed in such models.

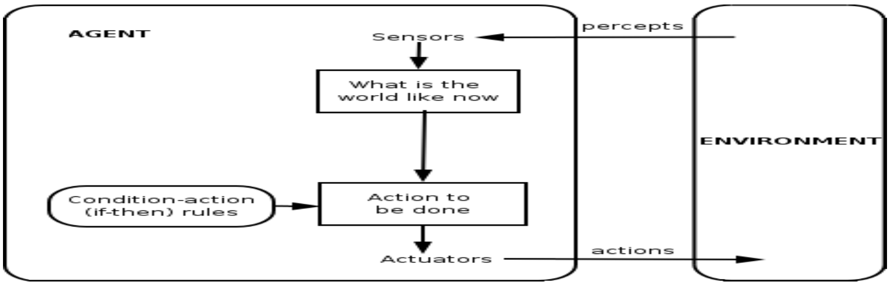

Fig 1: A simple reflexive agent

Agent-based modeling and simulation (ABMS) is a new approach to modeling complex systems by dividing them into a set of interacting autonomous agents. ABMS techniques provide a rich framework for patterns, structures, and behaviors to emerge through the agent interactions. ABMS is arguably the only modeling technique that can simultaneously take into account the attributes and constraints imposed by geography of roadways, the impacts of continually evolving social networks, and the changes from individual decision making and learning in transportation modeling.

ABMS use in transportation reveals that existing efforts can be classified into two main areas of applications:

1. Using ABMS to model ill-structured decision-making processes that cannot otherwise be accurately modeled. For example, modeling the evolution of driver's route-choice behavior, or safety-critical and aggressive driving. This is an area where rule-based or artificial intelligence (AI) ABMS techniques are suitable.
2. Using ABMS to better optimize the performance of the transportation system when solving the problem otherwise could be NP-complete or NP-hard. For example, optimizing a distributed control system. This is an area where cooperative agent techniques, such as game theory, are suitable.

The application of ABMS to transportation problems is an area that is still in its infancy in transportation area it will be expect to see many more applications of ABMS. As ABMS is the ideal tool to use to model complex systems, and given that the transportation system, where thousands of different types of agents interact on a continuous basis, is a very good example of a complex system. One of the most challenging technical aspects of ABMS is the identification of worthy aspects or problems for application of the technique—and not only applying the tools "because we Applying ABMS in existing optimization and simulation tools, translation of data and information or structure from one model to another will also poses a significant challenge with promising a enhanced possibilities.

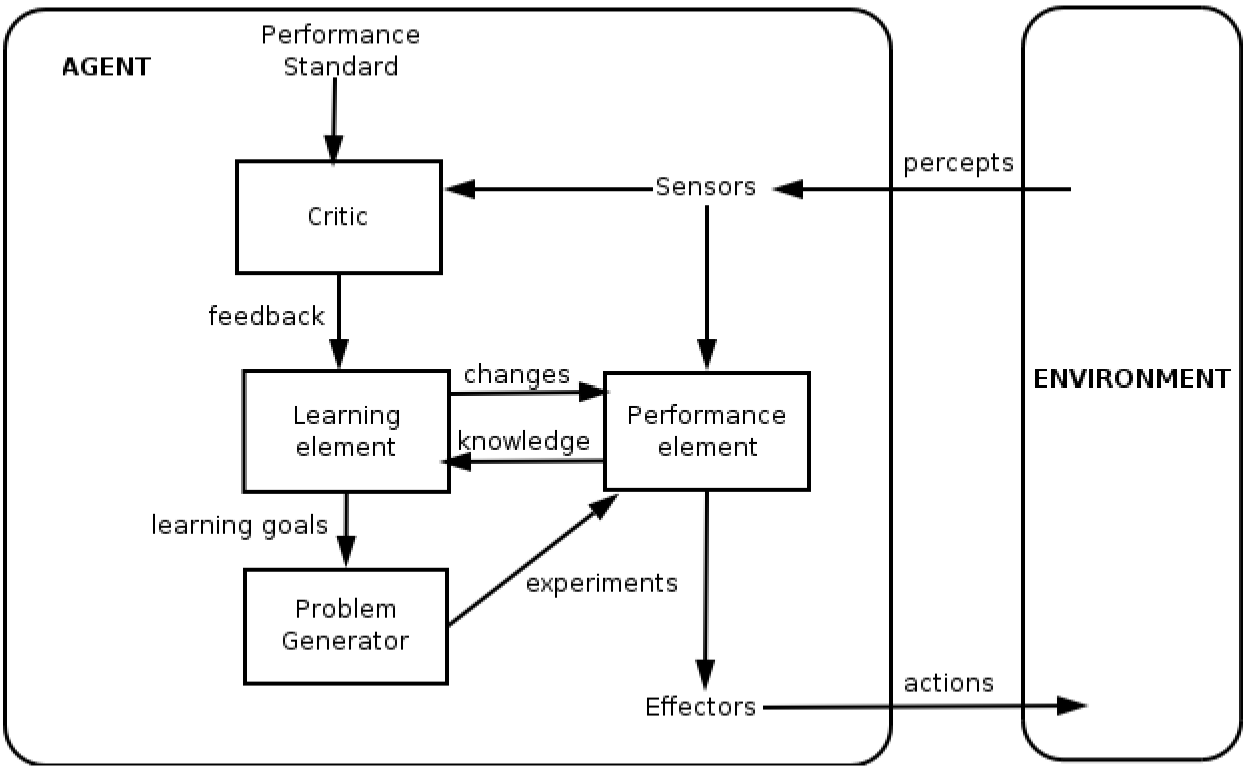

Fig 2: Learning Agent

Growing use of AI in the prospective social behavior researchers and practitioners have realized that single-agent systems, multi-agent systems, and distributed AI are widespread attractive, ranging from human–computer interaction over distributed problem solving to the simulation of social systems. Multi-agent principles, are ideal for building a wide range of computer applications, ranging from complex and time-critical systems to quite simple e-mail supervisors, which gives it an appropriate choice for traffic control system [4].

By modeling the separate instruments as intelligent agents, it might be possible to tune the actions of the individual instruments through the agent concept of collaboration. Letting the individual instruments handle the most basic forms of coordination automatically might also relieve the traffic operator.

There are two basic ideas[3]:

1) Consecutive ramp monitoring installations coordinate their actions to promote the flow at a downstream bottleneck.
2) Traffic management instruments coordinate their actions to attain a common goal on the network level.

Reinforcement learning, an AI method for machine learning, is used to provide a single, multiple, or integrated optimal control agent for both recurrent and non-recurrent congestion.

The study involved testing the methodology in three different applications:

1) Highway control using multiple ramp controls
2) Integrated corridor control with a single ramp
3) Variable message sign (VMS), and integrated corridor control with multiple ramps and VMS.

The microsimulation tool Paramics, which has been used to train and evaluate the agent in an offline mode within a simulated environment, is described. Results from various simulation case studies are encouraging and have demonstrated the effectiveness and superiority of the technique [2].

2.2 Fuzzy Logic Based Algorithms

Fuzzy logic algorithms appear well suited to highway entrance ramp monitoring because they can utilize inaccurate or imprecise information and allow smooth transition between monitoring rates. Inputs and outputs are descriptive (e.g., "no congestion," "light congestion," and "medium congestion") to allow for imprecise data.

Fuzzy logic systems use rule-based logic to incorporate human expertise. This way, it can balance several performance objectives simultaneously and consider many types of information, such as traffic conditions downstream, occupancy, flow rate, speed, and ramp queue. These capabilities allow fuzzy logic to anticipate the problem and take temperate and corrective action before the congestion occurs.

It has been shown that control of an urban expressway depends upon a skilled operator's judgment and decisions. The premier goal of the research was to investigate the effectiveness of fuzzy logic-based models in describing the operator's judgment process. A simple fuzzy reasoning model for on-ramp control and its performance were presented in their papers.

A fuzzy controller for highway entrance ramp monitoring and controlling that uses rules of the form: IF "freeway condition" THEN "control action."[1] The controller has been designed to consider varied levels of congestion, a downstream control area, changing occupancy levels, upstream flows, and a distributed detector array in its rule base. Through fuzzy implication, the inference of each rule is used to the degree to which the condition is true.

Using a dynamic simulation model of conditions at the San Francisco - Oakland Bay Bridge, the action of the fuzzy controller is compared to the existing "crisp" control scheme, and an idealized controller. Tests under a variety of scenarios with different incident locations and capacity reductions show that the fuzzy controller is able to extract 40% to 100% of the possible savings in passenger-hours. In general, the fuzzy algorithm displays smooth and rapid response to incidents, and significantly reduces the minute-miles of congestion.

3. CONCLUSIONS

This paper has surveyed the application of some AI paradigms to the problem of highway entrance ramp monitoring and provided the control strategies using fuzzy logic based algorithms and agent-based algorithms. Results from the studies performed to evaluate such algorithms seem to indicate the promise of AI when applied in such a context.

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