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# Finding optimum route of electrical energy transmission line using multi-criteria with Q-learning

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ABSTRACT

Due to an increasing energy requirement the consideration of route determination is becoming important. The aim of this project is to find an optimum result considering its important criteria. Finding an optimum route is a complex problem. It does not mean the shortest path to the problem. It is important to find the best way under the criterion that is determined by experts. Because of this we did not use the classical shortest path algorithm and we applied one of algorithms of the Artificial Intelligence. In this work, Geographic Information System (GIS)-based energy transmission route planning had been performed. In this optimization, using Multiagent Systems (MAS) which is a subdirectory of Distributed Artificial Intelligence the multi-criteria affecting energy transmission line (ETL) had been severally analyzed. The application had been actualized on the Selcuk University Campus Area. Therefore, the digital map of the campus area particularly had been composed containing of relevant criteria. Using Q- learning Algorithm of Multiagent System the optimum route had been determined.



## 1. Introduction

Nowadays, the establishment of ETL is becoming important, in order to meet the increasing energy requirement. Particularly, increasing urbanization and electrical power lost, decreasing fertile agricultural land and electric waste makes the optimum route very important when ETL is established.

ETL is determined according to some criteria such as; the least cost, using minimum power of work, infertile land and minimum damage to environment and nature. Using GIS is an advantage to select the alternative routes according to these criterias (Durduran & Aydin, 2007).

GIS has been used throughout the world in global, regional, and local environmental studies. These systems allow the capture, storage, processing, and display of an unprecedented quantity of geographic and spatial information and a wide variety of environmental and cultural phenomena (Reis, Nisancı, & Yomralıoğlu, 2009).

GIS data consists of both graphic and related descriptive data which are also considered to be attributes. A number of techniques are used to capture graphic data, including land surveying, photogram metric, remote sensing, and digitizing. As for the attributes, they are automated either separately and/ or linked to the graphics through unique keys, populated later or simultaneously during graphic data capture (Doner & Yomralioglu, 2008).

In light of the multi-criteria, we aimed to install a system to find the optimum route. So we used multiagent architecture.

Multiagent System (MAS) is one of the sub-disciplines of Distributed Artificial Intelligence (DAI). Distributed Artificial Intelligence (DAI) is examined according to the two disciplines (Weiss, 1999); Distributed Problem Solving (DPS), Multiagent Systems (MAS).

DPS, focusses on the information management taking place in the systems consisting of subsystems solving different problems and MAS is also interested in the behavior management of agent or object that is working together and an independent agent (Stone & Veloso, 1997).

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors. Also an agent is a computing system that is capable of autonomous action in this environment in order to meet its design objectives (Wooldringe & Jennings, 1995).

An intelligent agent can react to the goal that is chosen for it. Also an intelligent agent communicates with the other agent in the same environment as shown in Fig. 1 (Wooldringe & Jennings, 1995).

Agents had been used to resolve many problems with their features. However, with the problems in real life usually more than

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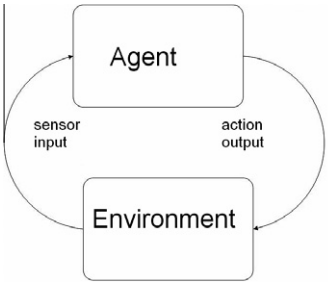


**Fig. 1.** The agent takes sensory input from the environment, and produces as output actions that affect it.

one agent influence each other. If more agents come together for the same aim, multiple agent systems are formed. So using MAS is more realistic and easy solutions can be found. By this way MAS is formed and solutions are more realistic and easy. In our work every criterion is thought as an agent. The criteria are dynamic and some times related to each other.

Additionally, using common shortest path algorithms, such as the Dijkstra algorithm (Gallo & Pallottino, 1986) and A* (Pearl, 1988) may also yield solutions that are not appropriate for users (Abolghasem & Kyehyun, 2009). Actually our purpose is not to find the shortest path. It is important to find the best way under the multi-criteria which is determined by experts. This problem was solved using *Q*-learning Algorithm which is an algorithm of Reinforcement Learning (RL). In the next section *Q*-learning Algorithm is described.

## 2. Geographic Information System (GIS)

GIS has been used since the 1960s for city planning, utility management, facility management, hazard management, address matching, agriculture and crop estimation; applications in geology, hydrology, biology, archeology, forestry, emergency services, social/medical studies, transportation, and the military field (Aronoff, 1989).

GIS is a system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatial referenced on the earth. According to Aronoff, GIS is any manual or computer-based set of procedures used to store and manipulate geographically referenced data.

The relationship between GIS and computer-aided design, computer cartography, database, management and remote sensing information systems is important in establishing a definition of GIS. It is sometimes argued that GIS is a subset of or a superset of these systems (Fig. 2) (Maguire, 1992).

GIS can be applied to many types of problems. Rhind (1990) sets out a general classification of the types of generic questions which GIS frequently uses to investigate (Table 1) (Maguire, 1992).

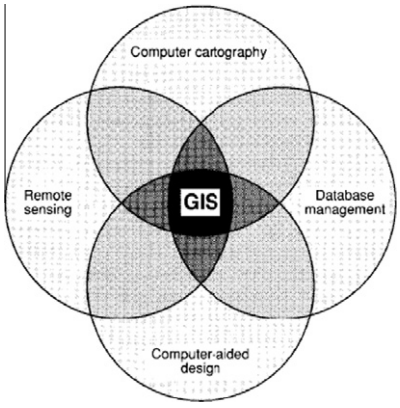


**Fig. 2.** The relationship between GIS, computer-aided design, computer cartography, database, management and remote sensing information systems.

## 3. *Q*-learning Algorithm

When intelligent agents are planning some learning methods are used. These are Planning Learning (PL), Supervised Learning (SL), and Reinforcement Learning (RL).

Reinforcement Learning is the problem faced by an agent that must learn behavior through trial-and-error interaction with a dynamic environment (Kaelbing, Littman, & Moore, 1996).

*Q*-learning is an algorithm of RL that can be applied to areas to be modeled to Markov Decision Process (MDP). Problem of RL can be modeled as MDP. MDP is described as the variables below (Kaya, 2003):

$S$, set of possible states.
$A$, set of actions.
$s$, state.
$a$, action.
$r$, reward.
$\pi$: $\rightarrow S \times A$ is state transaction function.

An agent is interacting with its environment (Fig. 3). The agent exists in an environment described by some set of possible states $S$. It can perform any of set of possible actions $A$. Each time it performs an action $a_t$ in some state $s_t$ the agent receives a real-valued reward $r_t$ that indicates immediate value of this state action transition. This produces a sequence of states $s_i$, actions $a_i$, and immediate rewards $r_i$ as shown in Fig. 2. The agent's task is to learn a control policy, $\pi$: $\rightarrow S \times A$, that maximizes the expected sum of these rewards, with future rewards discounted exponentially by their delay (Mitchell, 1997).

**Table 1**
Basic questions that can be investigated using GIS.

| | |
|---|---|
| Location question | What is at ...? |
| Condition question | Where is it ...? |
| Trend question | What has changed ...? |
| Routing question | Which is the best way ...? |
| Pattern question | What is the pattern ...? |
| Modeling question | What if ...? |

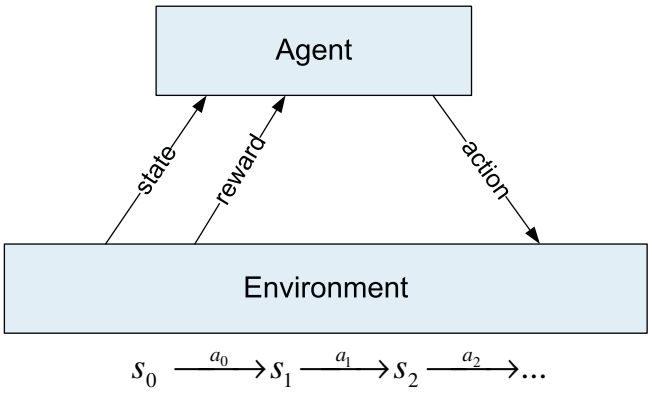


**Fig. 3.** Reinforcement Learning.