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ScienceDirect

Procedia Computer Science 110 (2017) 190–198

Procedia Computer Science

www.elsevier.com/locate/procedia

The 14th International Conference on Mobile Systems and Pervasive Computing (MobiSPC 2017)

Toward an Efficient Ambient Guidance for Transport Applications

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Abstract

We address smart transportation systems whose computational process is based on autonomous and context-aware intelligent agents. As a use case, a pharmacy round tour application is presented, then an original guidance algorithm is proposed to handle the various intentions to be executed during a delivery mission. The efficiency of the algorithm relates to a combined approach involving planning, learning and physical path optimizations. In particular, the past experiences of actions are used to better select the plan which guides the driver contextually. Moreover, the move actions in the plan are concretely refined on shortest physical paths taking into account the spatio-temporal evolution of the driving context.

Keywords: Ambient system, context-awareness, transport problem, BDI agents, planning guidance, reinforcement learning.

1. Introduction

Driver assistance applications are interesting services to be proposed in smart cities[1]. The hardness of developing such applications directly depends on the fact that the city road systems often appears to be ambient, open to any vehicle and subject to any change of situation, sometimes unexpected. Current solution usually consists in making the vehicles safe of collisions and efficient w.r.t. its basic actions. A graphical navigation interface is used in different situations to help the user's driving, moreover maps are used to show the current traffic on roads, e.g.[2].

In this paper, we propose to go a step further by taking care of specific driving missions.In particular, a pure contextual assistance could not be safe nor efficient when some long-drives are required. For instance, the pre-selection of some route by taking the instantaneous traffic information into account could not be appropriate throughout the whole travel, because of the traffic changes.

Multi-agent approaches have provided interesting solutions concerning the assistance topics[3,4]. Mainly, some agents are embedded in smart environments to assist users in their daily tasks and anticipate their needs[5]. Each agent can be designed as a very powerful entity, so that the user can directly takes profit from the autonomous and

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1877-0509 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.06.084

proactive capacities of the agent. Among the possible agent architecture, the BDI ones allow reasoning in terms of agent intentions (I), coming from the agent Beliefs (B) and Desires (D)[6]. To guide the user efficiently, the agent must be context-aware of its environment in order to react to the context changes and adapt its behavior[7].

In this paper, we focus on an agent-centric approach, where the assisting BDI agent is equipped with a powerful planner service. In that, we follow the work of[8] enhancing how the so-called *Higher order Agent* (*HoA* for short) is adapted to ambient dynamic systems by formalizing the capacity to reason then produce an optimal action plan to guide the assisted user. Mainly, the planning mechanism is not only contextual but also learns from the past-experiences of the performed actions. According to the formal approach of this solution, the management of intentions allows for an automatic and tuned re-planning from the context changes[9].

Up to now, the HoA approach was experimented considering a virtual environment, like in[10]. To assist user, our purpose is now to consider real information coming from the ground space. More particularly, we aim at proposing a new algorithm, called *TCL* for *Transport with Contextual Learning*. It plans the user activities based on a learning model of actions while the move actions are refined in efficient routes through the city road-map. Up to our knowledge, there is no seminal work proposing an equivalent ambient service, moreover, we show how to integrate the interesting information and services of a road-map server.

Another interesting point of this paper is its aim to accelerate the prediction of an optimal execution plan, despite the fact that the performance of actions strongly depend on spatio-temporal situations. Because our approach allows an evaluation of every action under spatio-temporal conditions, we are able to propose an on-the-fly planning mechanism using both execution learning and standard scheduling mechanisms.

It should be noted that certain classical approaches searches for efficiency by handling the selection of actions under statistical analyses or deep learning approaches about previous executions e.g.[11], however this is not very applicable when the environmental context can change at real time, sometimes unexpectedly. Other related works concentrate on the execution cycle of a BDI agent to dynamically promote the execution of some next intention and associated plan, e.g. in[12]. These introduce efficiency at execution time against intention failures but does not focus on a user guidance problem.

The remaining part of the paper is organized as follows: Section 2 introduces a realistic scenario used as a frame example, playing with a pharmacy delivery driver mission. In Section 3, we briefly present the different processes involved in an HoA agent, which are connected now to a road-map service. Section 4 recalls how the contextual planner builds a plan of the agent from its intentions. Moreover, Section 5, focuses on the acquisitions of action past-experiences and on their exploitations. In Section 6, we detail the *TCL* new planning algorithm, which computes an optimal action plan to guide the user. The last section concludes and outlines some related perspectives.

2. The Pharmacy Delivery Scenario

Pharmacies must have the capacity to offer whatever diagnosed drugs, therefore a distribution circuit is usually organized to supply them, for instance once a day accordingly to the pharmacy orders. Fig. 1 is an illustrative example of what could be the road-map used by the smart agent to contextually guide the delivery driver. This road-map is viewed as an abstract graph. Nodes represent physical map locations: the deposit (*full square*), pharmacies (*full circles*), and simple connexion points (*empty circle*). Each edge represents a road section in between 2 locations and there may be different types of edges to feature bidirectional or unidirectional ways (resp. *simple line* and *directed edge*). Moreover, some duration estimations are highlighted through the graph: a duration is associated with each section to mention the time to cross the section and each pharmacy node is associated with a possible time to deliver the drugs.

Every day, the objective of the delivery driver with his truck consists in reaching the pharmacies that require some drugs, then in coming back to the deposit to park the truck. In our approach, the delivery driver is assisted by an electronic device which embeds a smart agent. Basically with that agent, the driver can be well informed at real time of the current roadworks and traffic flow on the different sections. The agent also includes an efficient contextual planner to help handling the pharmacy tour prerequisites. Some driver preferences can be taken into account, like for instance going downtown early in the morning when this is necessary.

The core difficulty to make a plan of a day tour is to predict some heavy traffic and try avoiding it. Actually, it could be interesting to anticipate and compute the best plan according to the durations to spend when crossing the