HP Scientific communication course – Spring 2019 – Assignment on common ground.

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Paper

*Title: Multi-Agent Path Finding with Removable Obstacles**
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*Working in progress: title may change. Note that this paper doesn't belong currently to literature.

Abstract (Technical version)

Multi-Agent Path Finding (MAPF) is a critical AI topic and has many applications. Classical MAPF is limited to practical applications that involved only a static fixed environment. In this paper we introduce the concept of reconfigurable environment. Whereupon we focus then on environments with removable obstacles. Pathfinding with removable obstacles is a problem that is currently being studied from a geometric point of view. We introduce then a new optimal solver based on *Conflict-Based Search* (CBS) algorithm to effectively solve *Multi-Agent Path Finding with Removable Obstacles* (RO-MAPF) problems.

Abstract (Extended version - Common ground version)

Image an Amazon warehouse where a robot is looking for the teddy bear you have ordered. Several robots are moving in the environment and we must prevent agents from bumping into each other. This problem is known as the *Multi-Agent Path Finding* (MAPF) problem, a challenging Artificial Intelligence topic that deals with finding non-interfering paths for multiple agents, each one with a start and goal location in a shared environment. By agents, we mean entities able to perform movements, such as physical robots or non-player characters in a videogame like ghosts in Pac-Man. MAPF can model many real-world problems in warehouse logistics, office robots, videogames and more.

Different solvers are available for solving MAPF problems. One of the most recent and popular MAPF solvers is the *Conflict-Based Search* (CBS) algorithm. It is among the fastest algorithms for solving MAPF and it is always able to find the optimal solution when it exists. By optimal solution, the best possible set of collision-free paths, one per each agent, is meant. The typical approaches to MAPF problems are based on two main assumptions: (1) the environment is static and (2) the environment can't be modified. This is a strong limitation because real-world environments are neither static nor unmodifiable. The classic Bomberman arcade game, for example, is a game that is set in an environment with dynamic and removable obstacles on a map where agents are supposed to move. The first assumption has been overcome with *MAPF with Dynamic Obstacles* approaches.

In this paper, we show an approach to overcome also the second. In our approach, we define the concept of reconfigurable environments, namely environments that can be modified, at will, under certain conditions. Whereupon, we focus on reconfigurable grid-based maps with destructible obstacles, assuming that some obstacles have an associated removal cost and can just be removed from the environment by paying this cost.

Hence, in this problem, called *Multi-Agent Path Finding with Removable Obstacles* (RO-MAPF), we are given a budget that can be spent on removing obstacles.

RO-MAPF are problems quite difficult to solve. Consider the 15-puzzle game. We can see tiles as agents and address this puzzle as a MAPF problem. Clearly, this problem is difficult to solve optimally and RO-MAPF is hard too since it is a generalization of MAPF. Nevertheless, in this paper we present an effective algorithm, which is an extended version of the CBS algorithm, able to solve RO-MAPF problems optimally.

Main message of the article (30 words)

Some robots located in a shared environment want to reach a certain position. Every robot needs a safe path to follow. The novelty is the possibility of modifying the environment