Course 16.412- Cognitive Robotics Henry Lefebvre de Plinval-Salgues
PS #1

Part A

I am fascinated with the following topics:

*Path Planning:
I am interested in learning answers to the following questions:
How to plan a shortest / fastest / cheapest path in a known map to reach a goal ? How to include constraints, like moutains / threats ? How to deal with unpredictable threats ? How to make a smooth path from a coarse path (for instance drawn by a human being as a draft) ?

*SLAM
How to build a map of the robot's environment while locating itself on it ? Which strategy for team of robots performing SLAM (like: half of them moving, the rest remaining as landmarks, etc) ?

*Voice & Vision
I am fascinated with the idea of a robot being able to interpret its vision / noise environment. I would like to learn more about how a robot can deduce from a snapshot of its environment the things that are actually surrounding it. I would like to learn more about the strategies to identify a known object when it is hidden or seen from another point of view. I would like to learn how the voice recognition softwares work.

Part B

Basically, I am fascinated with intelligent systems related with aeronautics and space.

My dream scenario could be: a **group of Unmanned Aerial Vehicles** (planes or helicopters), performing a **rescue in a moutainous area**.

The UAVs would have to **plan a path** to find the people they are looking for: in some scenario, they can have a precise position (through GPS safety device for instance), but in some others, they would have to set a strategy to scan the whole area methodically.

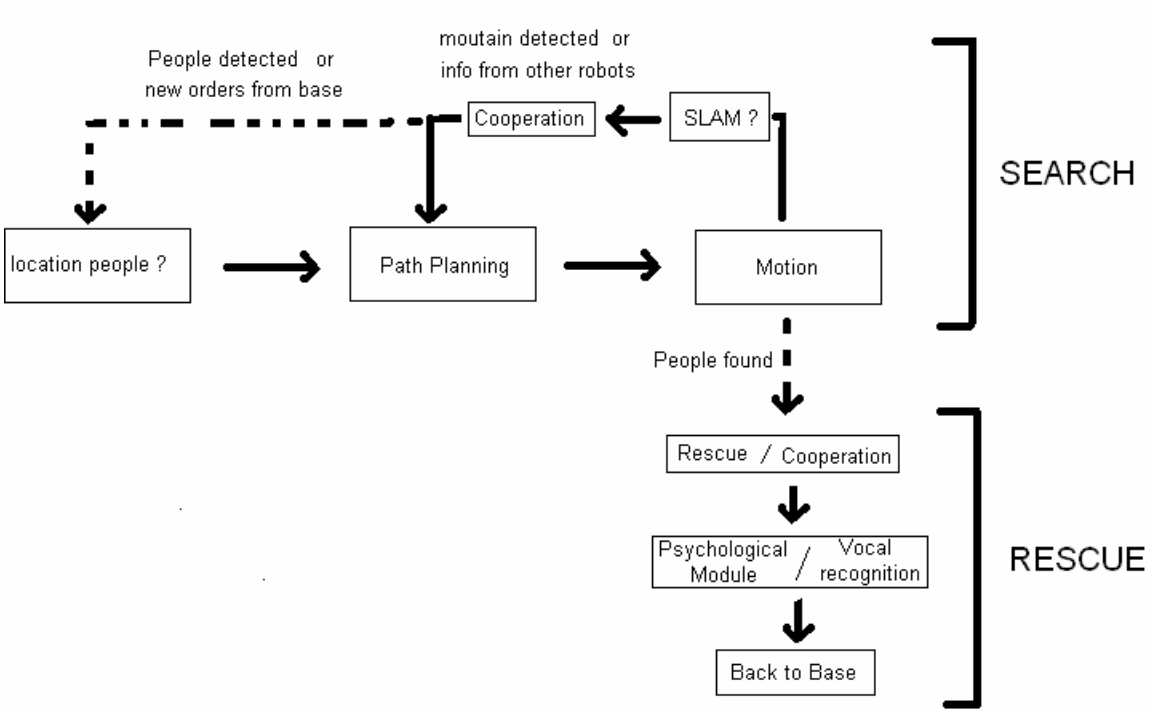
They would have in some missions a precise knowledge of the position of the obstacles, and in some others no knowledge. In the later case, they would have to perform **SLAM**. In both cases, they should be able to include to their map new obstacles not mentionned before.

They should **cooperate** together to broadcast data about obstacles, people to rescue, area already scanned, and might need each others to perform the rescue.

They may also be able to **understand new orders** given by human beings coordinating their action from Headquarters.

They would also ideally include some **vocal recognition software** to understand the people they are saving (if they have for instance a special need, or if their legs are broken and some special care is to be taken), and also a **psychological software** to take care of the people possibly shocked by their trial.

Architecture Diagram:



Another idea could be a group of military UAVs having a target and cooperating to attack them at the very same time, while avoiding threats (known or pops-up).

Part C

The most important reasoning capability is the **path planning** part.

Indeed, the very first thing that we ask our UAVs to do is to find the peope.

This capability consists of being able to set a path, either to the known position of the people to rescue, or to methodically scan the whole area. In both cases, the UAVs need to be as fast as possible, while taking the obstacles into account. Some new obstacles may appear, since their map may be incomplete.

Another dimension of this capability is the cooperation within the team, although I don't see if it is too ambitious for this project. The UAVs should be able to broadcast their new knowledge about obstacles, areas already scanned, position of the people… They also need to avoid collision with each other.

Part D

Paper 1

Title

Experimental Demonstration of Multiple Robot Cooperative Target Intercept, T W McLain, R W Beard, J M Kelsey

Why I chose this paper

I chose this paper because it deals with path planning for a team of robots cooperating to attack several targets at the very same time. This topic is obviously close to my project in that it implements path planning for a team of robot. Moreover, the constraints in this paper are close to those in my project: threats here are similar to the presence of mountains in my projects. Pop-up threats are similar to mountain not present on the robots's map.

Major contributions

Its major contribution is to show an experimental demonstration of the concept. The robots achieve to plan their path in cooperation so as to reach the targets at the same time. The paper present a method to write the goal in a way that makes the decentralization easy. It presents also a way to generate kinematically acceptable paths.

Strengths

The paper presents a decentralized control strategy for the team to reach the targets together. It presents a method to generate trajectory according to the kinematic constraints. It shows the success of experiments made on those principles.

Weaknesses

The control strategy is not explained very well.

Relationship with the system I want to implement

In this paper, a team of robots plan their paths to targets they want to reach at the very same time. In my project, I will also work on path planning, and, if possible, also for a team of robots. The threats that the robots in this paper want to avoid are similar to the mountains my robots will avoid.

Paper 2

Title
Probabilistic Path Planning for UAVs, A Dogan

Why I chose this paper
This paper presents a probabilistic approach to path planning, which I find interesting. It also presents a smart way of making the trade-off between the length of the path and the probability to be shot down by the threats.

Major contributions
This paper presents a new probabilistic approach to path planning for a team of UAVs. It makes such a parametrization of the problem that the user can easily make a trade-off between his desire for a short path and his frighten of the threats.

Strengths
The approach being probabilistic, it can be used in the same way for pop-up threats, without changing anything.

Weaknesses
The method presented does not avoid limit cycle in the paths. Even though it detects them, it is too late.
Also, the local minimization method does not provide an optimal path.

Relationship with paper1
This paper covers another aspects of my project: it deals more with the way of representing the constraints / threats. Also, it is for a single robot, not for a team as paper 1.

Relationship with the system I want to implement
I am interested in the idea of using a probabilistic description of the moutains. In my project, the robots may have or not a map. In any case, this map is not perfect, so a probabilistic description may fit well with my goal.

Paper 3

Title
Applying Kinodynamic Randomized Motion Planning with a Dynamic Priority System to Multi-Robot Space Systems, C M Clark, T Bretl, S Rock

Why I chose this paper
In this paper, a new dynamic priority system is presented. Thanks to it, the robots whose environment is the most crowded has the highest priority to plan its path.

Major contributions

This paper shows a new method to avoid collision: instead of the static priority system existing before, it presents a dynamic priority system, where the robots whose environments are the most crowded can decide their paths before others.

Strengths
Thanks to the algorithm presented in this paper, a large team of robots can perform path planning while avoiding collisions, by setting cleverly the priorities between the various robots.

Weaknesses
No special weakness noted.

Relationship with papers 1 and 2
This paper is more interested in collision avoiding, while paper 1 deals with cooperation to reach the goals at the same time. Paper 2 dealt with a probabilistic representation of the constraints.

Relationship with the system I want to implement
In the system I want to implement, I need a strategy to set the priorities in the team of robots. For instance, if the position of the people to rescue is unknown, they have to cooperate, in a certain priority order, to scan the whole area.

Part E

For my project, I would like to design an intelligent code for UAVs trying to rescue people lost in mountains, while avoiding obstacles.

There are various levels in this project, which I could do depending on how hard they are:
-at a first level, one helicopter (here a point with basic kinematic restrictions) planning the fastest path to reach a known goal, in a known moutainous environment.
-adding unknown threats.
-having the goal uncertain / completely unknown.
-adding other helicopters to cooperate (share map updates / people position updates / threats knowledge updates).
-adding helicopter-like behaviour for the motion / adding fuel constraints.
-adding altitude changes.
-multiple people to save.
-being as far as possible reachable by radio from the base.

I guess I could do the 3~4 first points. However, I do not know how ambitious it is.

I will actually pursue this project, or maybe do something slightly different and still related with Aeronautics/Space (for instance a team of UAVs attacking a target/several targets in ennemy territory). However, again, I do not know what is interesting or not, ambitious or not in this project.