COMPSCI 773 Assignment 2

Due Date: Wed, 02 October 2002

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The goal of this assignment is:

1. To perform the motion planning for the robot-car.
2. To recognize a small set of hand signs.
3. To write a driver to use the firewire DV camera port for image acquisition.

This assignment is a continuation of the previous assignment and is intended as a further step towards the overall project goals.

The first part of assignment 2 is a motion planning problem. Starting from a fixed given position you will have to plan a path for the robot-car to take it through the bridge, under the tunnel and park safely in a given position. Hand posture recognition will be the first step to car-control. In this assignment you will have to identify a few hand postures you will acquire with one of the two DV Sony cameras. Part 3 of the assignment is optional and may help you to accelerate the hand posture recognition task. You may write a driver to use the firewire connection between the camera and PC for videostreaming.

Path and Motion Planning

You should now use the upper left corner of the field as world reference frame coordinate origin.

Using the initial position of the car, the location of the bridge, obstacles, tunnel and a given final parking position you should plan the path (if it exists) of minimum length joining the initial and desired final position of the car.

Requirements:

- **The car has a fixed given initial and final position.**
  - It is therefore a problem of single shot motion planning
- **The car should pass the bridge at least once.**
  - Both direction allowed.
- **The car should go under the tunnel at least once.**
  - Both direction allowed.
- **The car should avoid 3 obstacles which will be randomly placed in the field.**
- **The car MUST not cross the boundaries of the field.**
- **The positions of the bridge and tunnel are not fixed (they will be moved around before the start of your demo).**
  - **3D Positions of objects in the field should be computed beforehand via patch and line detection.**

Path Planning

Using non holonomic constraints, cell decomposition of the field, wave front algorithm and any other methods you may find in the literature, you should trace one of the shortest path joining the start and goal position of the car. Your interface should display the (shortest) path the car is supposed to follow with the exact position of the different objects present in the field.

- Your path might be decomposed into straight lines and turns of constant radius.

- You may also use cusp movements.

Hints

- If you decompose the field into cells, take into account the size of the car and its turning ability to allow diagonal movements between cells and/or expand obstacle cell prints (check your motion control lecture notes).
- Explore the geometry of cusp movement to find the shortest space necessary to perform a turn or change the direction of the car

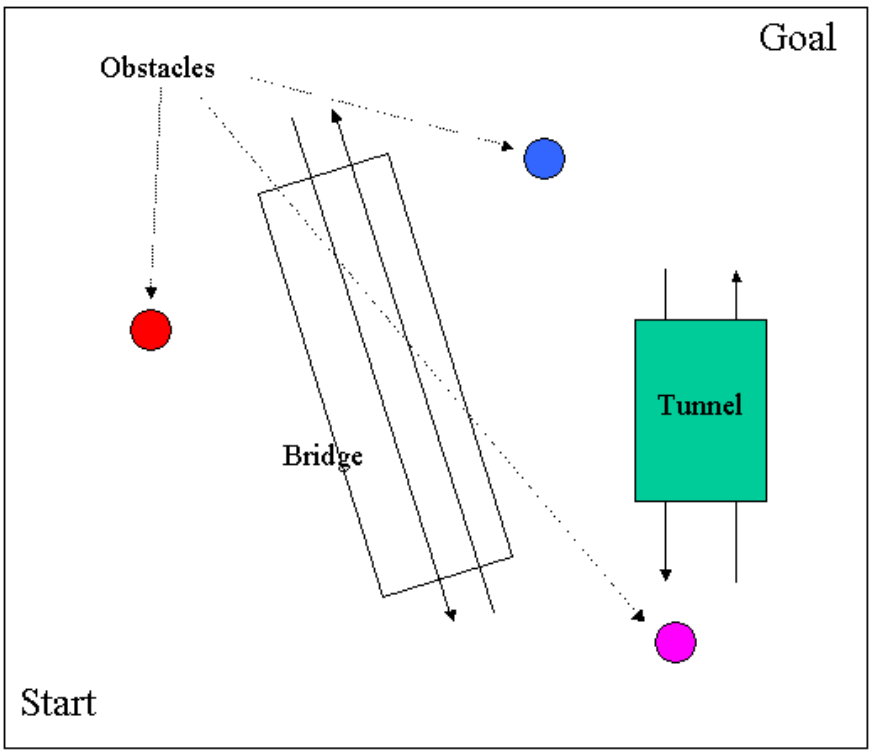
Motion Planning
Requirements:

- Move the car along the planned path.
- Control car position and speed.
- Adapt the path to the car capabilities (turning radius, speed).

The 3D position of the car will be computed with the help of the videoserver via patch detection:

- you are allowed to use the videoserver to find the color thresholds for each given patch in the field.
- The videoserver doesn't give you the 3D position of the patch center but the position of a point lying on the ray passing through it.

Patches should be attached to the car. It is up to you to design a new patch object that will be attached to the car or to use one of those created last year. When the car move along the required path, you should compute its updated 3D positions. It will be your task to keep the car moving along the trajectory computed beforehand. You will have to take into account turning radius limitation of the car and you may assume its velocity to be constant during turning operations. You should also estimate the position of the car regarding its current position, velocity, acceleration to avoid wide deviation from the path to follow.



The field

In this representation of the field, 3 obstacles (you should have already created them during the Assignment 1), a bridge and a tunnel are displayed. For a given start and goal you need to find a feasible path which will take the car on the bridge, under the tunnel while avoiding the obstacles and staying within the limit of the field

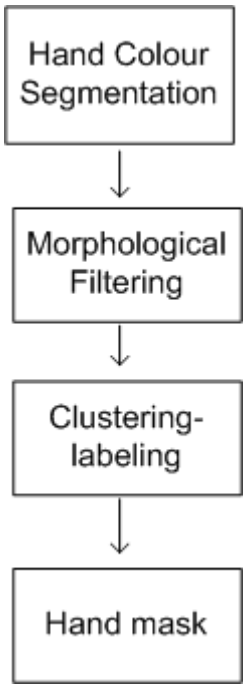
Hand Posture recognition

You will have to create a list of signs that you want to recognize. Five or six different signs should be enough for our project.
your goal will be to classify any given hand posture as part (or not) of your sign alphabet. This will be related in the next assignment to the car control.

For this part you should use the DV cameras available in the lab. You should recognize a small set of hand postures (**static** hand configuration) in a reasonable amount of time. The user should be asked to make a sign in front of the camera and the system should return the corresponding classification of the sign within a range of seconds. To ensure good results, you should more or less follow the following requirements:

- Hand postures are formed in a plane **parallel** or almost parallel to the camera.
- **No additional illumination** sources are used.
- Individuals are instructed to form sign in front of the camera with **no restrictions on the distance** between the hand and the camera.
- **No colour markers/gloves.**
- User Independence – Your system **must not be sensitive** to differences in posture due to **anatomical variation** of the users or **differences** in the performance of a specific posture by the users.
- you may ask the sign maker to make a posture at a given time.
    - you are not supposed to deal with gesture (dynamic signing) but posture (static signing).

You should start with the following steps:



Gareth Barton's report describes different methods for the above steps. Your goal will be to comply with real-time constraint, therefore you need to avoid time consuming algorithms and use the simple solutions. His report also lists work that you may read for further ideas.
Once you obtain the hand masks, you should associate a given mask to a corresponding sign. You may use:

- Template matching
    - Maximize the correspondence between your hand mask and the generic masks of each given

sign of your alphabet.
- Finger tips
  - The number of finger tips detected should help you to find the sign if your alphabet has been created in such a way (a different number of finger tips for each sign for example)
- PCA (Principal Component Analysis)
  - Widely used, widely published, code certainly available on the web (you are allowed to use it)

You may explore different ways to perform this posture recognition task but keep in mind the real-time constraint and stick to efficient techniques.

Firewire driver

This part is optional and should be completed only if the previous ones are fully working.

You will have to design the driver which should pilot the firewire port.

At the moment, the videoserver uses the v4l2 interface to capture video from the capture cards. We would like to add support for ieee1394 (aka firewire) based digital video cameras.

The following resources may be useful:

- **library for capturing data from ieee1394 devices:**
  - **http://sourceforge.net/projects/libraw1394**
    - **It may be possible to use video1394 to capture the data, instead of raw1394. This would be faster as it uses Direct Memory Access (DMA).**
  - **http://libdv.sourceforge.net/ - library for decoding digital video (dv) data (it is compressed).**

Both of these libraries are installed on toyota (the only machine with the ieee1394 capture card).

Submission

You should submit your assignment as a printed and electronic report (one per group) before the due date. Once again the title page of your report should identify all the students and the corresponding parts of the report each student wrote. Introduction, conclusion and comments should be group work.
The report itself should include the following parts:

The new parts developed with respect to the work previously done in the previous assignment
Description of algorithms used for the different parts.
Description of your programs.
Description of your experiments.
Conclusions and/or comments.

Demos

Each group will show a demo on the week the assignment is due. Their interface should provide 3D position of objects and the planned path regarding the position of the bridge and tunnel. The car should then automatically reach the goal while following the given path. As for the hand posture demo, I will produce signs in front of the camera and your systems should classify them in a reasonable amount of time.