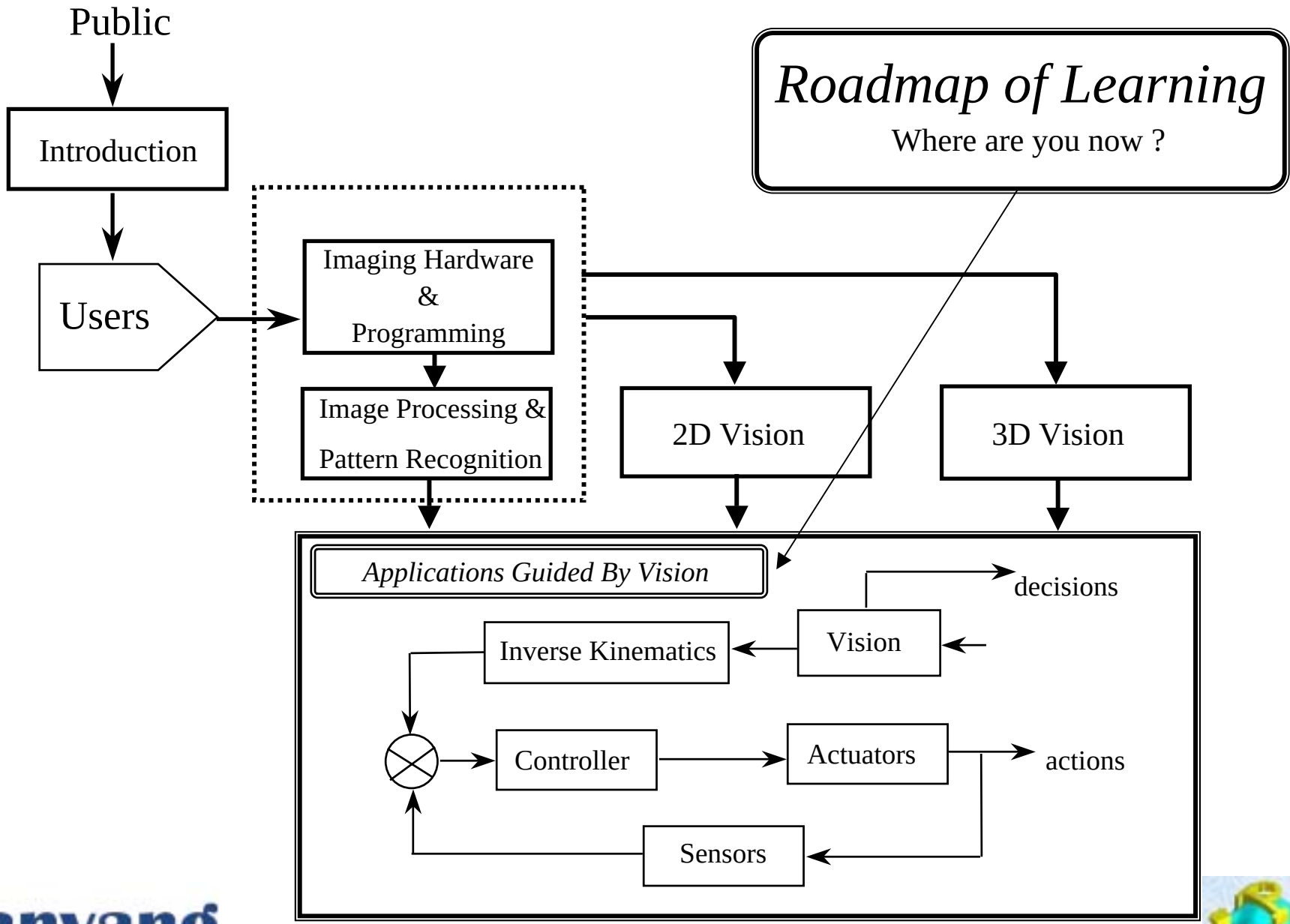
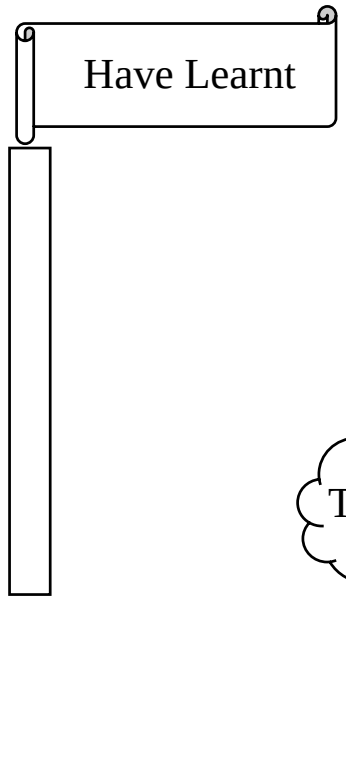


CONTENT



What can be done with a machine vision system ? (A Review)

ANSWER:

Visual Guidance:

To obtain a geometric (full or partial) description of a scene necessary to the safe planning and control of the movement of machine (eg, robot).

Visual Inspection:

To obtain photometric and/or geometric measurement of goods or parts or machined outputs (like printing) for the sake of ensuring the highest quality if possible.

Visual Measurement:

To obtain photometric and/or geometric measurement of machined outputs for different purposes (inspection, surveillance, etc)

Visual Identification:

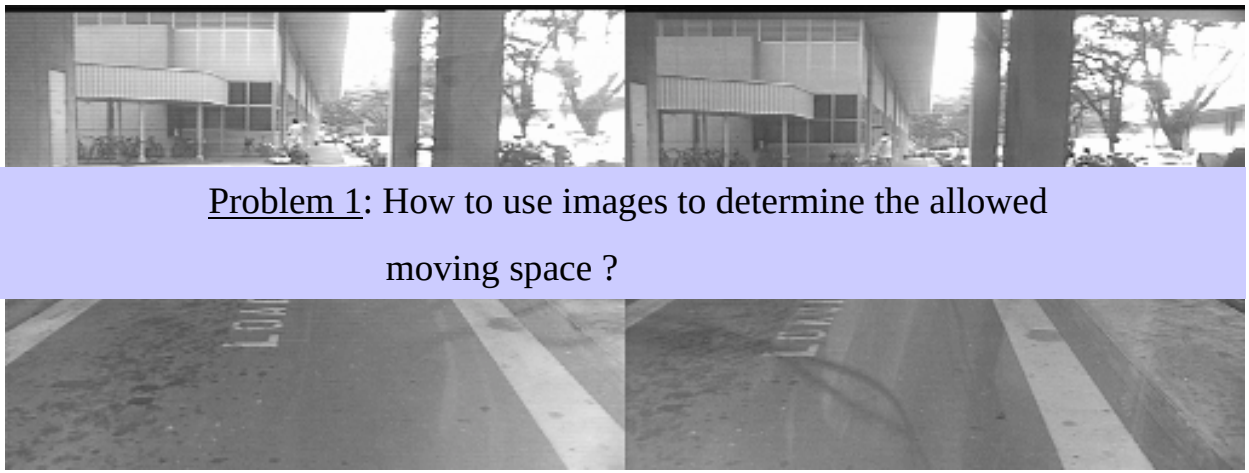
To obtain metric features from images for the sake of identifying the belonging of objects under the viewing.

Visual Guidance of Vehicle

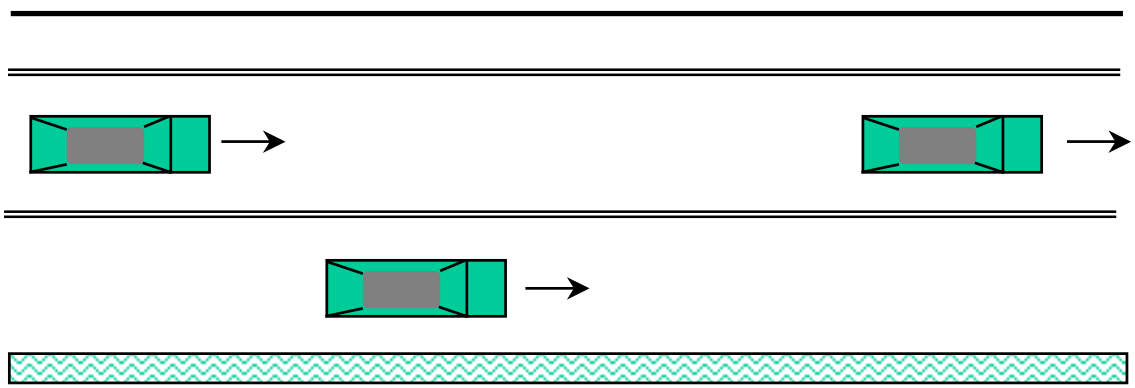
1. Illustration:

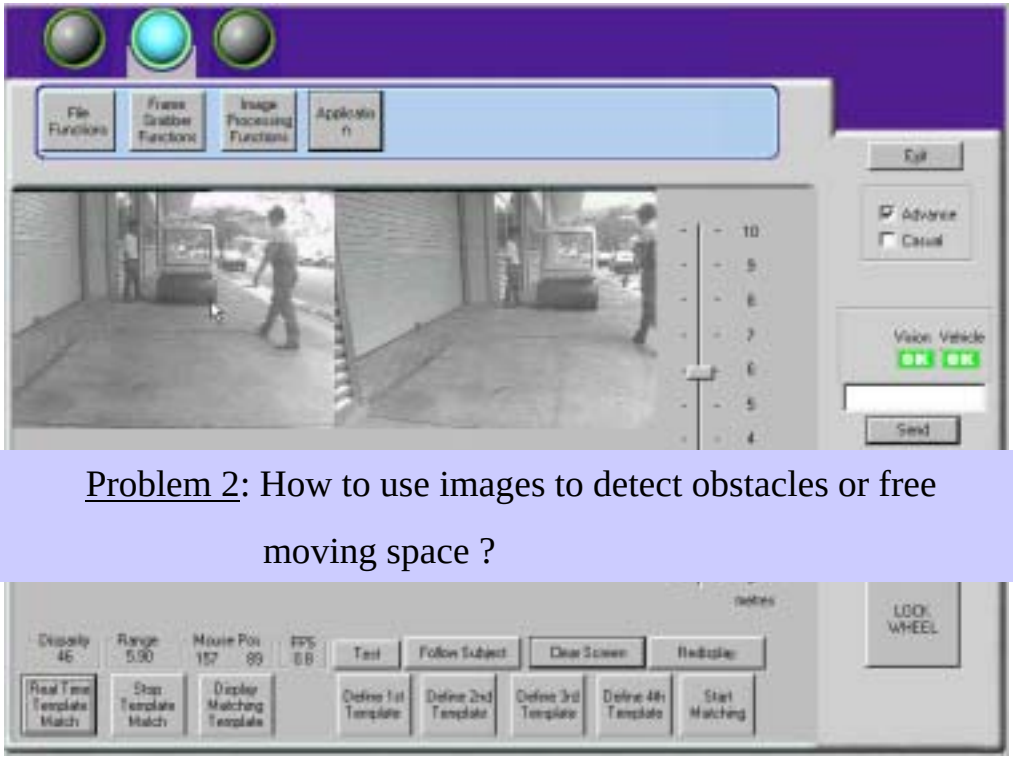
Visual Guidance of Vehicle

2. Problem Statements:

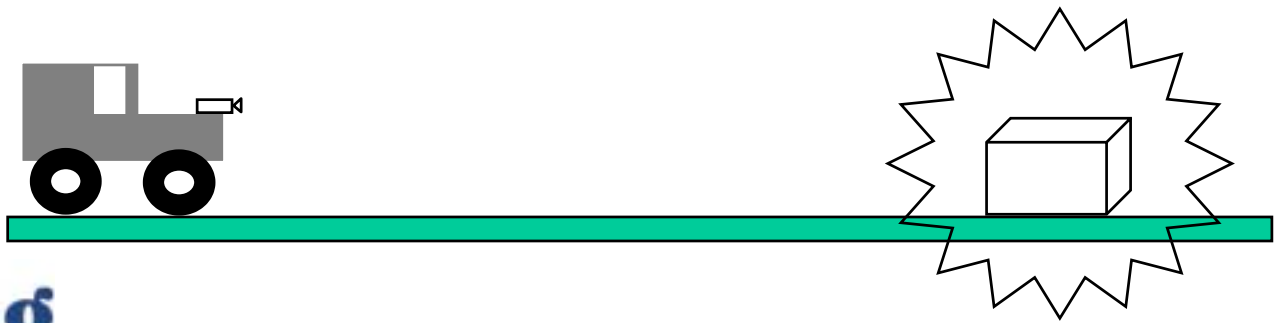


Problem 1: How to use images to determine the allowed moving space ?





Problem 2: How to use images to detect obstacles or free moving space ?

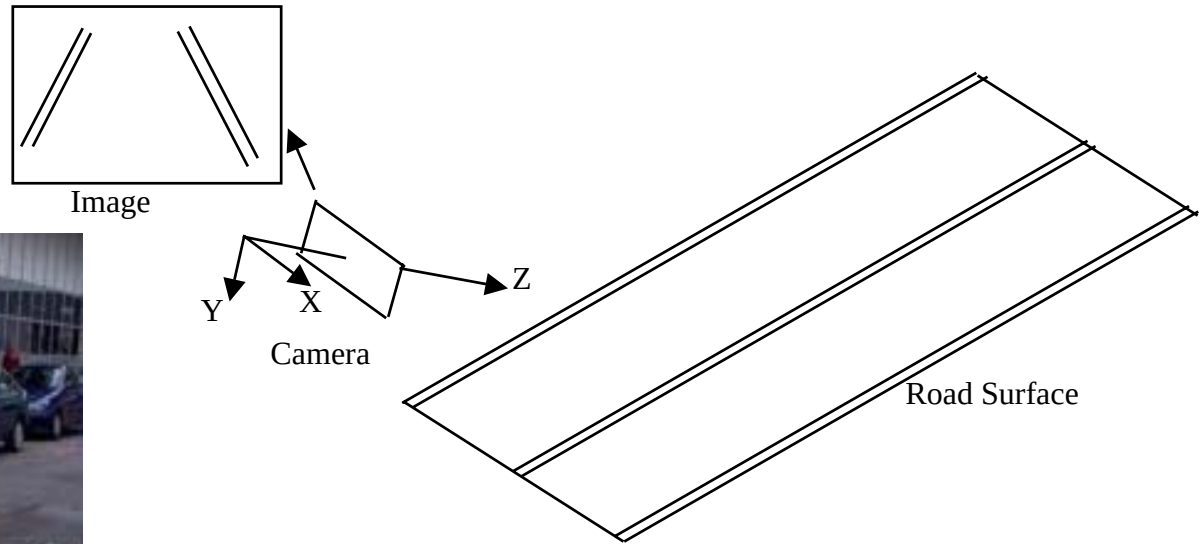


Visual Guidance of Vehicle

3. Vision Techniques: Road Geometry Estimation

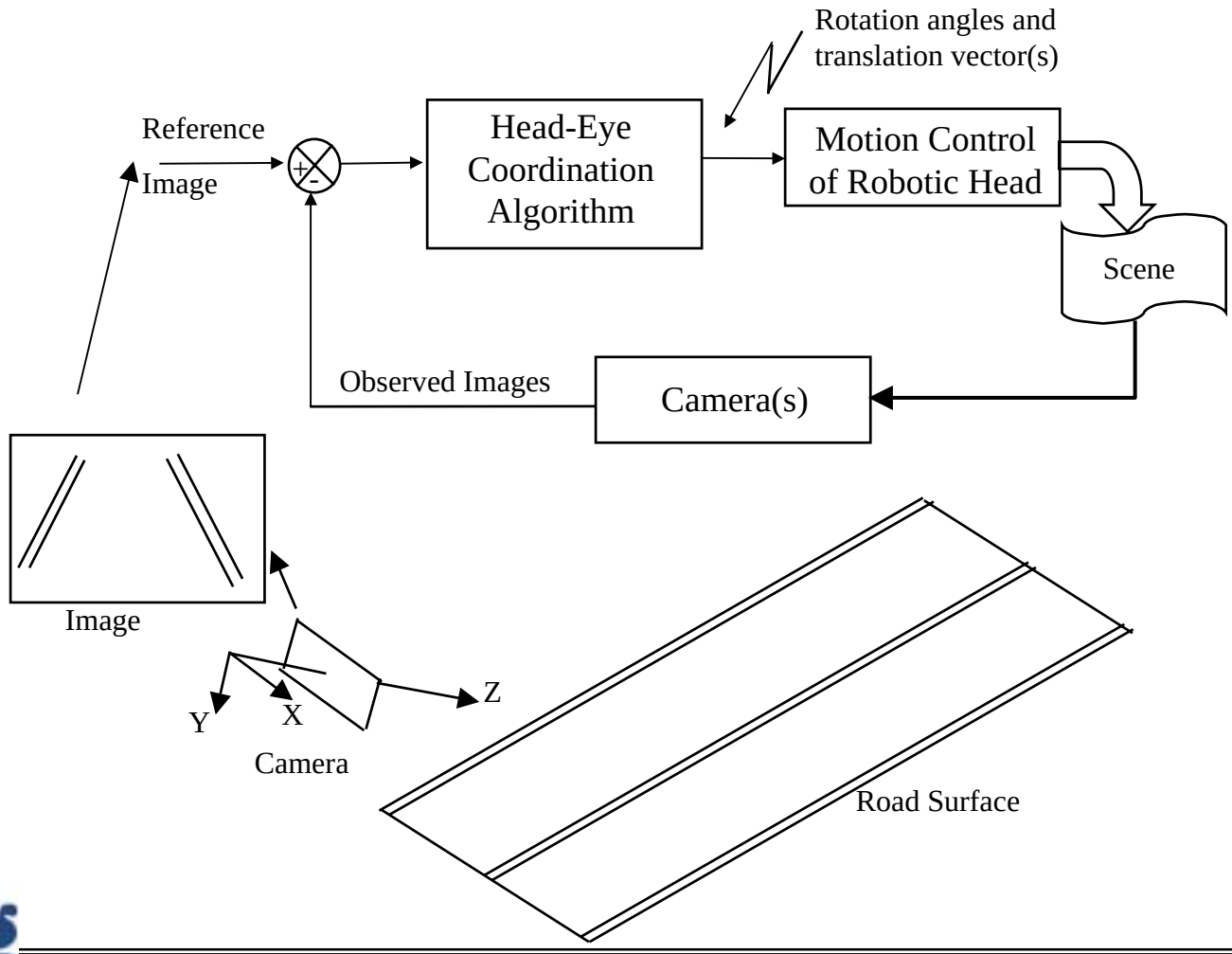
a. System Setup: - Assume that the road surface in the proximity of a vehicle can be approximated by a plane.

- A vision system with one camera is mounted on vehicle.



b. Solution 1: "Head-Eye Coordination"

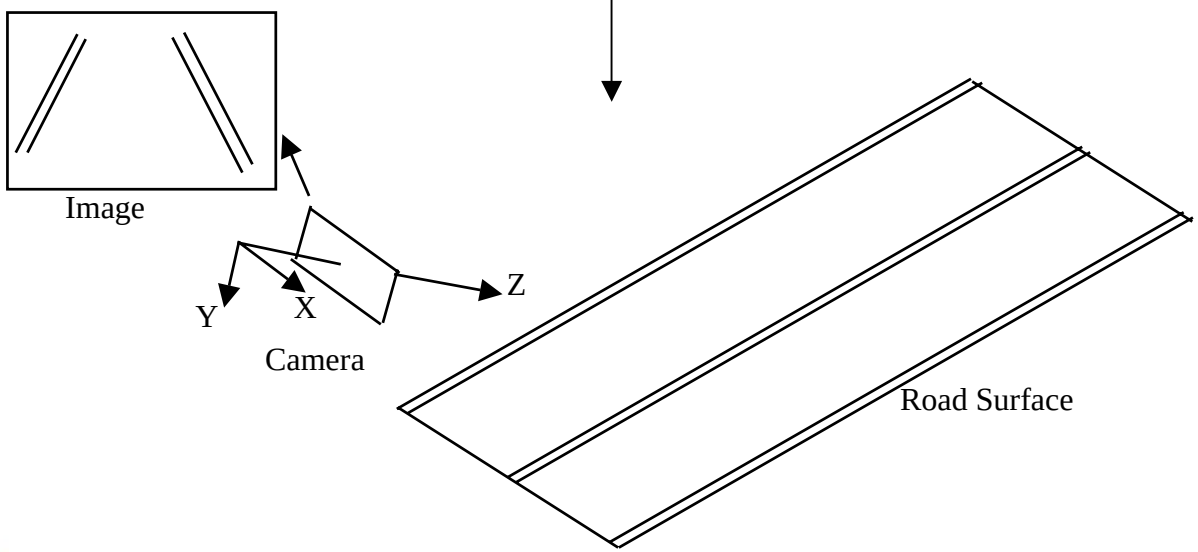
If the camera is not calibrated, we choose one image as a reference image. Then, the problem becomes "Head-Eye coordination" and can be solved by an iterative method.



b. Solution 2: “2D Vision”:

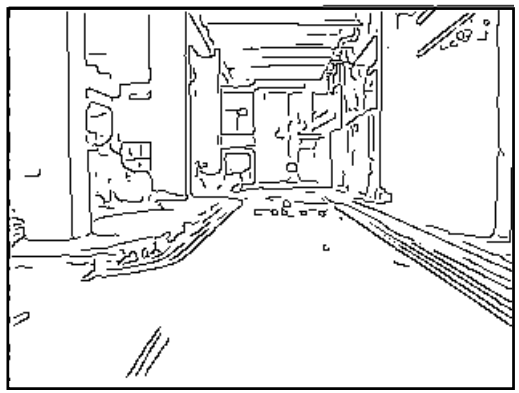
If the camera is calibrated, the image coordinates can be back-projected onto the road surface by using a 3x3 calibration matrix.

$$\begin{pmatrix} k \bullet X \\ k \bullet Y \\ k \end{pmatrix} = M_{3\times 3} \bullet \begin{pmatrix} u \\ v \\ 1 \end{pmatrix}$$

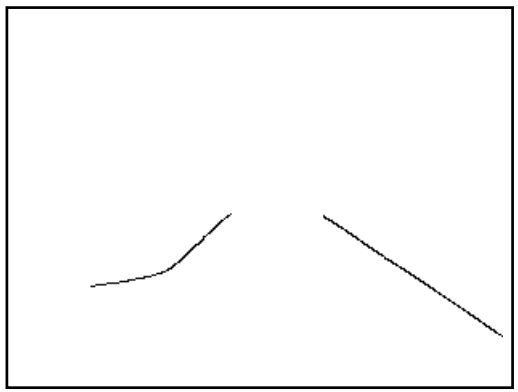


c. Experimental Results (smart vehicle):

Image



Edgemap



Left and Right Chains

c. Experimental Results (mobile robot):

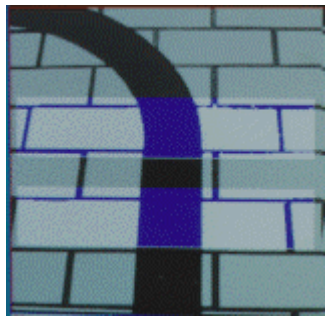
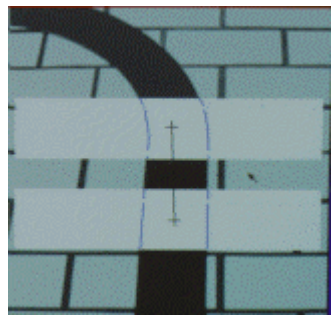


Image taken at Time T1 with two binarized sub regions.



Detected central line of road mark from the two sub regions.

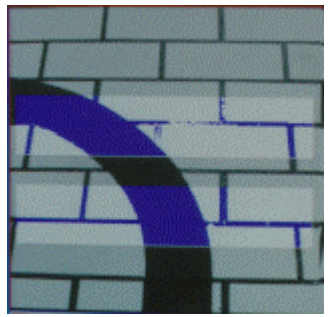
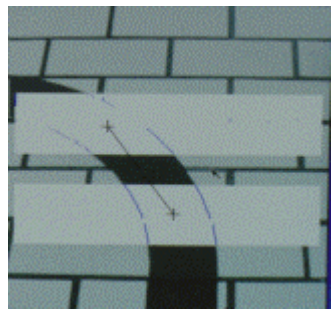


Image taken at Time T2 with two binarized sub regions.



Detected central line of road mark from the two sub regions.

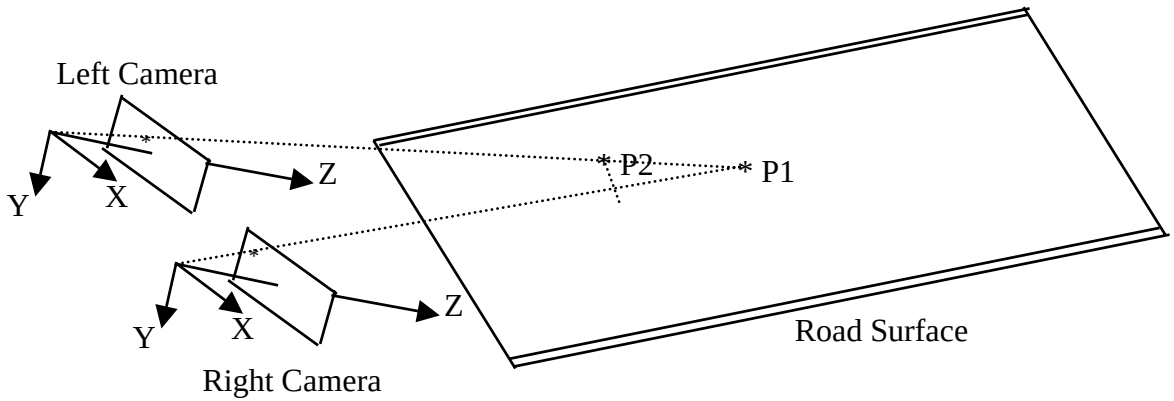
Visual Guidance of Vehicle

4. Vision Techniques: Obstacle Detection

a. System Set-up: - Assume that the road surface in the proximity of a vehicle can be approximated by a plane (ground plane).

- We consider that an obstacle is an object that is located above the ground plane. (Anything inside or blow the ground plane is not obstacle).

- A vision system with two cameras is mounted on vehicle.



b. Solution description:

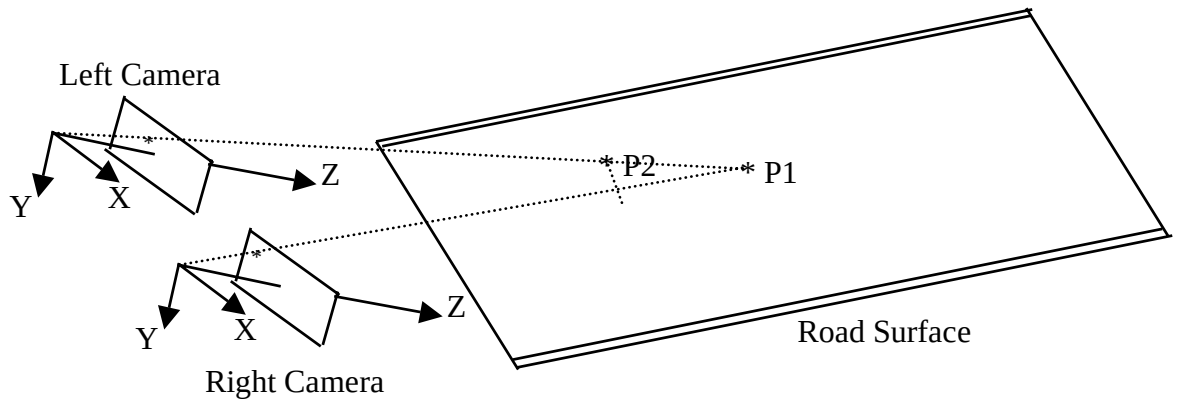
Step 1: Assume that there is a point on the road surface.

Step 2 : In the left camera, we have the following relationship :

$$\begin{pmatrix} k_1 \bullet u_l \\ k_1 \bullet v_l \\ k_1 \end{pmatrix} = M_{3\times 3} \bullet \begin{pmatrix} X \\ Y \\ 1 \end{pmatrix}$$

Step 3 : In the right camera, we have the following relationship :

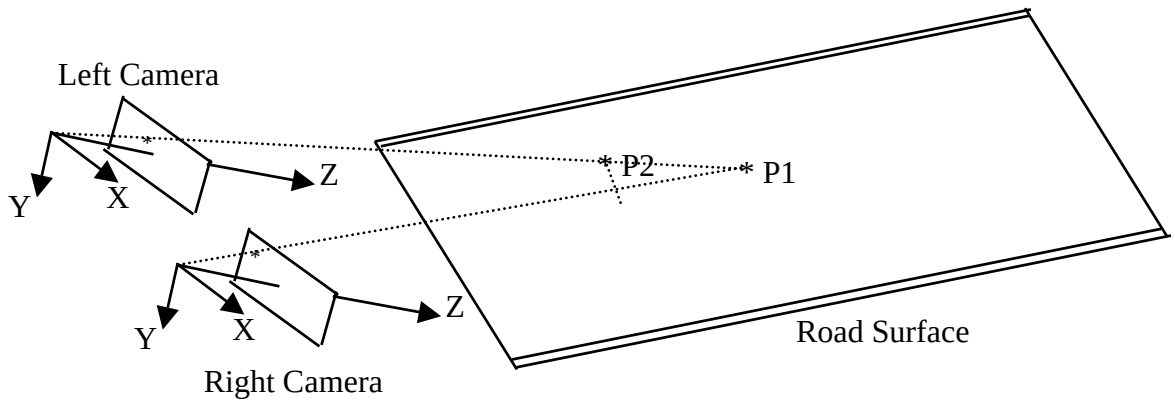
$$\begin{pmatrix} k_2 \bullet u_r \\ k_2 \bullet v_r \\ k_2 \end{pmatrix} = N_{3\times 3} \bullet \begin{pmatrix} X \\ Y \\ 1 \end{pmatrix}$$



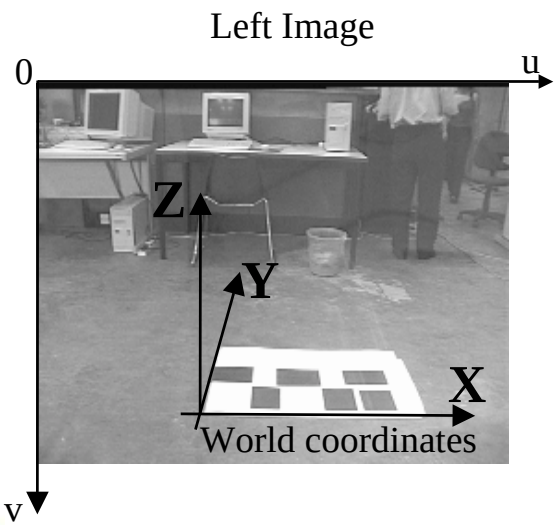
Step 4 : The combination of the above two equations yields :

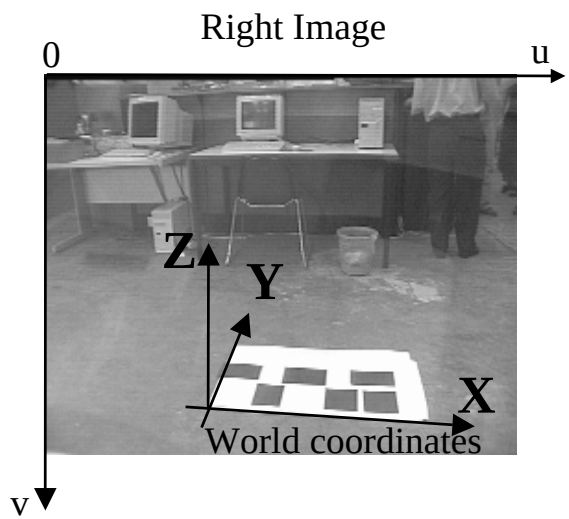
$$\begin{pmatrix} k \bullet u_l \\ k \bullet v_l \\ k \end{pmatrix} = M_{3\times3} \bullet N_{3\times3}^{-1} \bullet \begin{pmatrix} u_r \\ v_r \\ 1 \end{pmatrix}$$

Step 5 : The above equation describes the necessary condition for a point to be located on a ground plane.

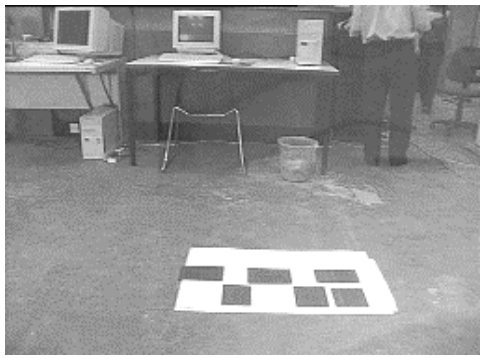


c. Experimental Results (smart vehicle):



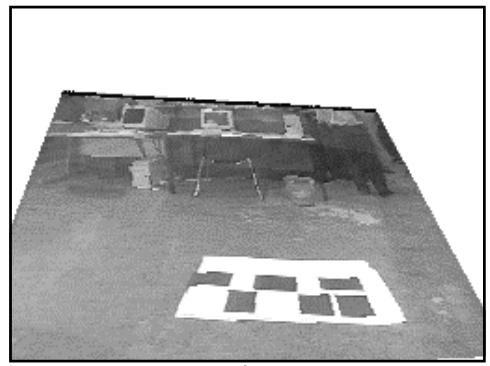


Left Image

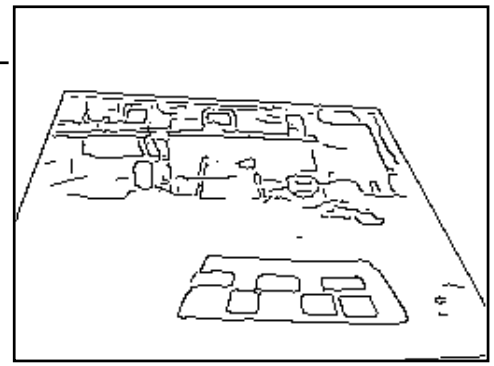


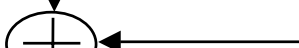
Right Image

Projected Image

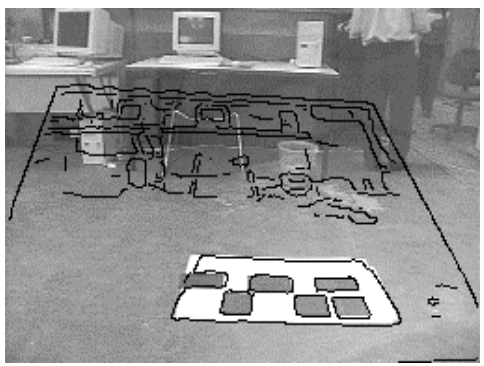


Edgemap

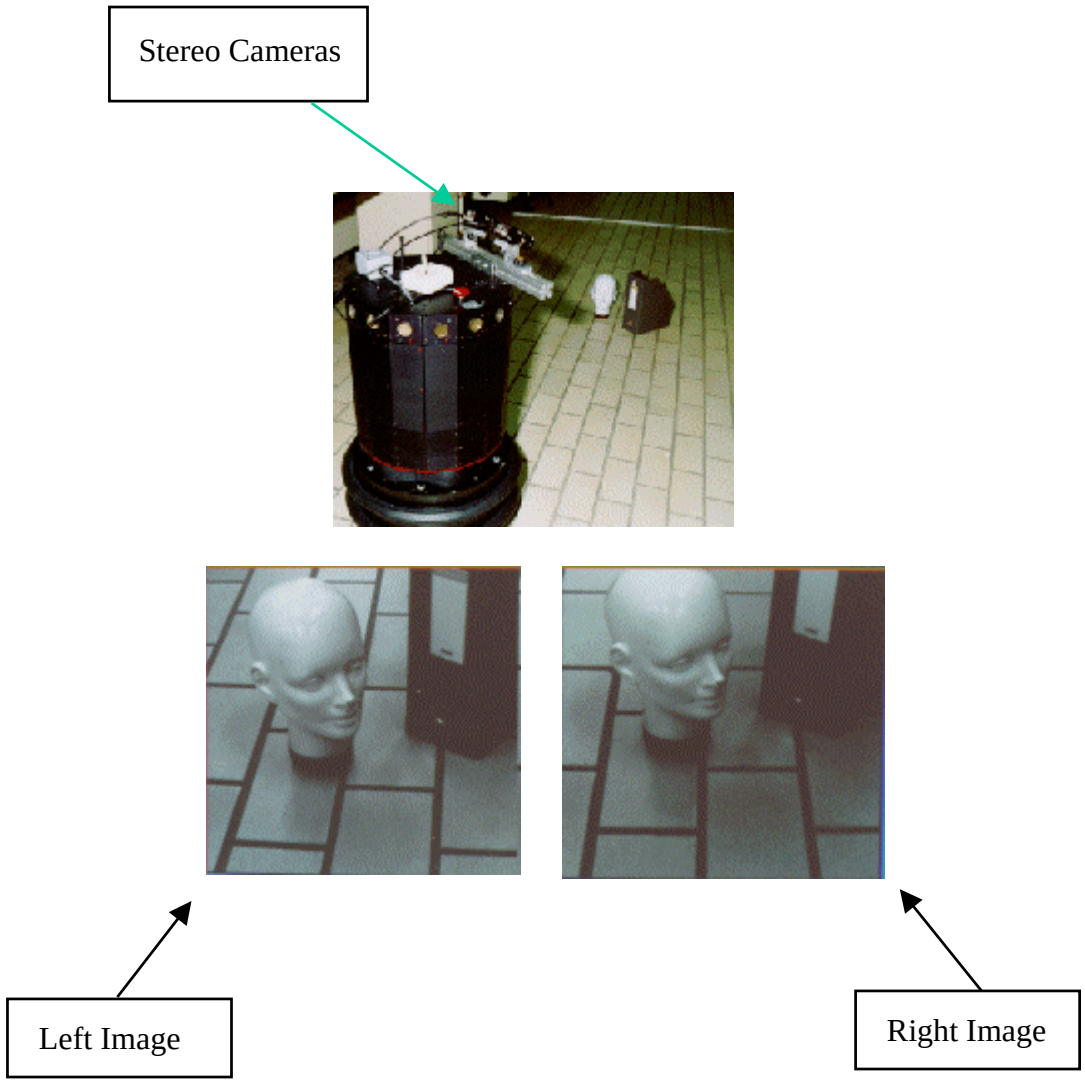




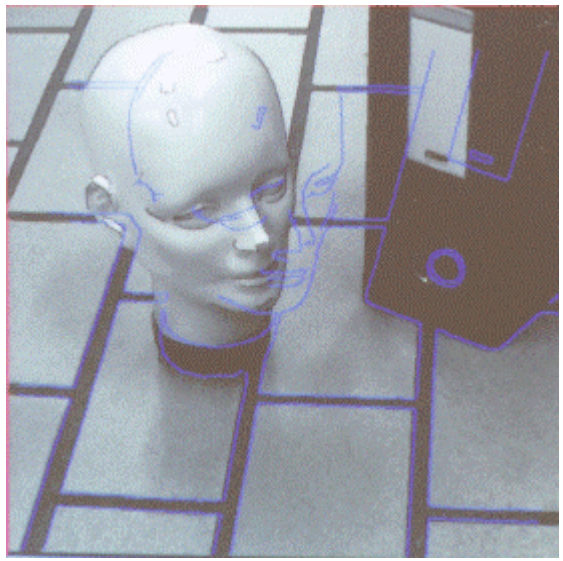
Superposition



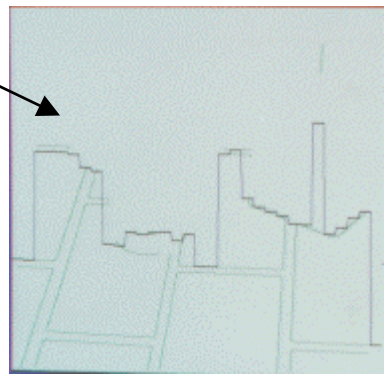
c. Experimental Results (mobile robot):



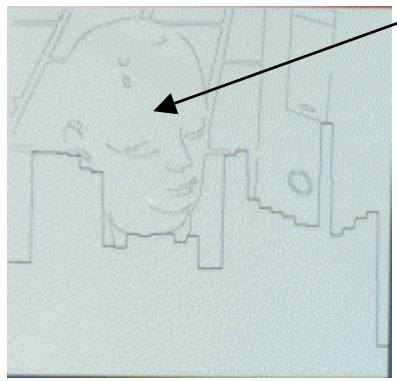
The projection of the right edgemap onto the left image.



Contour points located on the ground plane



Contour points belong to obstacles or occluded space.



SUMMARY

1. The two sub problems of visual guidance of vehicle are:
   a. How to determine the road geometry from images ?
   b. How to detect obstacles or free space from images ?

2. The basic solution to “road geometry estimation” is to apply the geometric principle of 2D vision. One can also use an iterative method of Head-Eye coordination to implicitly solve the problem.

3. Road obstacle detection is a more complicated problem. One basic solution is to make use of the constraint of “ground plane”. In this case, the left image of a ground plane is related to its right image by a 3x3 projective transformation matrix. This describe the necessary condition that a primitive located on the ground plane must satisfy.

4. Other useful methods for obstacle detection include:
   * Range sensor combined with CCD camera.
   * Qualitative stereo vision.