Dynamic Image Registration for Elevation Map Fusion

Background

Caltech's vehicle, 'Alice' competed in the DARPA Grand Challenge in October 2005.

Alice is equipped with a number of sensors, of particular interest are the

•Ladar

•Stereo vision

which are used to create an elevation map of the terrain around the vehicle.

Each sensor creates a separate Digital Elevation Map (DEM) from its range measurements.

Data from these multiple sensors is fused into a single cost (or speed) map for the path-planning algorithm.

Testbed : Alice

Problem

- As the vehicle moves across the terrain, the sensors (eg. stereo cameras) may get misaligned, making the original calibration invalid. Thus errors are introduced in the elevation maps, such as specific locations of obstacles, etc.

Proposed Approach

- To apply image registration techniques to correct for errors in this dynamic environment.

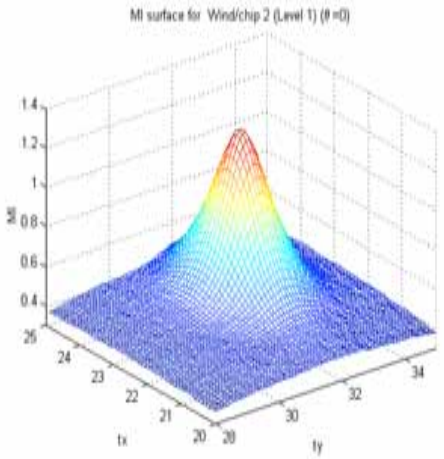
Dynamic Image Registration for Elevation Map Fusion

Image Registration using Mutual Information (MI)

For two images A and B the Mutual Information, I (A,B) can be computed from their joint histogram, $h_{AB}(a,b)$ by:

$$I(A,B) = (1/N)\sum_{a,b} h_{AB}(a,b) \bullet \log \frac{N.h_{AB}(a,b)}{h_A(a)\cdot h_B(b)}$$

where N is the number of pixels in image.



Mutual Information Surface

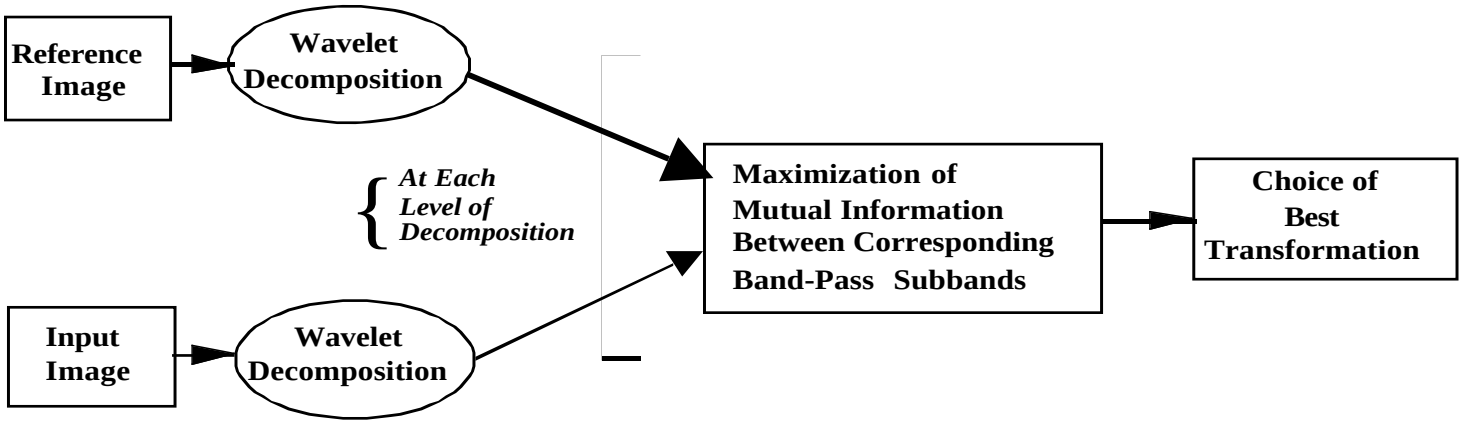


Image Registration using Wavelets

Dynamic Image Registration for Elevation Map Fusion

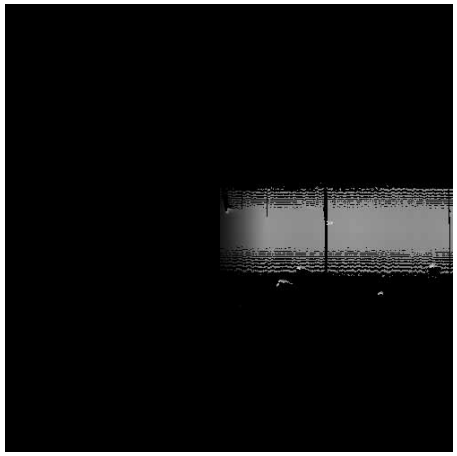
Approach to Solution

Using pairs of Elevation Map images from

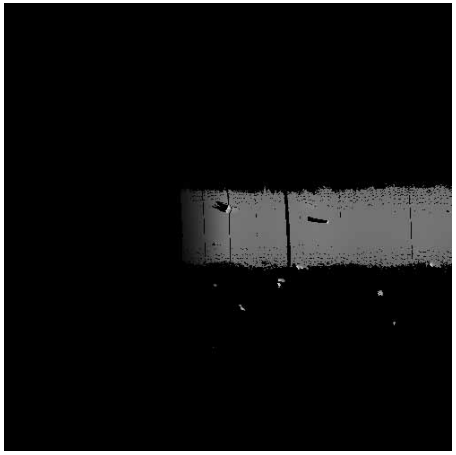
- Ladar (from 3 units)
  - *Front, Roof, Small* (taken at the same time instant), and
- Stereo vision cameras.

At position *(i,j)*, of image **A**, the pixel intensity a_{ij} denotes the *elevation (or height)* at that pixel location.

The image, **A** is registered to the image **B** to determine the parameters (tx,ty,θ) which align image **A** to **B.**



Front Ladar



Roof Ladar

Currently
Individual Elevation Map=> Individual Speed Map;
Fuse individual speed maps from sensors => Final Speed Map.
Alternatively
Register new Elevation maps from sensors =>
From *Fused* Elevation maps => Final Speed Map, and
Keep updating Speed map over time, using the new registration.