Detection and Tracking Experiment Design

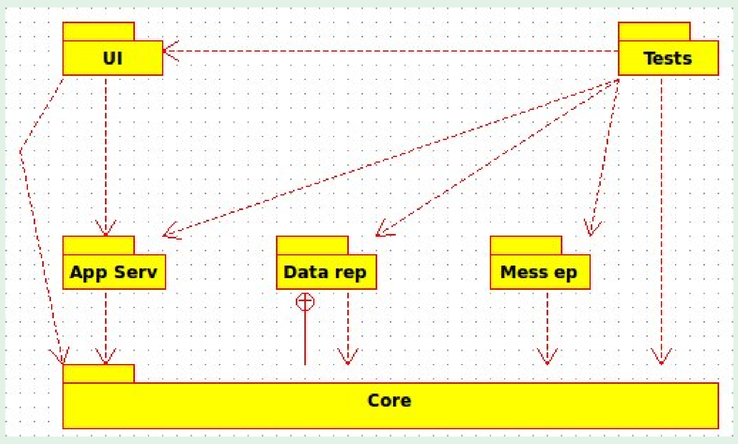
{Levente.Tamas, Cosmin.Marcu}@aut.utcluj.ro

Motivation

Several research work have been performed using laser-scanners in object classification and moving object tracking including but not limited to localization and navigation applications, guarding systems or military applications.
Although there are a great number of published papers about the mobile robot related measurements they often present only the results of the theoretical and practical investigations. However a well designed experiment setup is essential in order to have a good dataset on which further data processing can be carried out

Software architecture

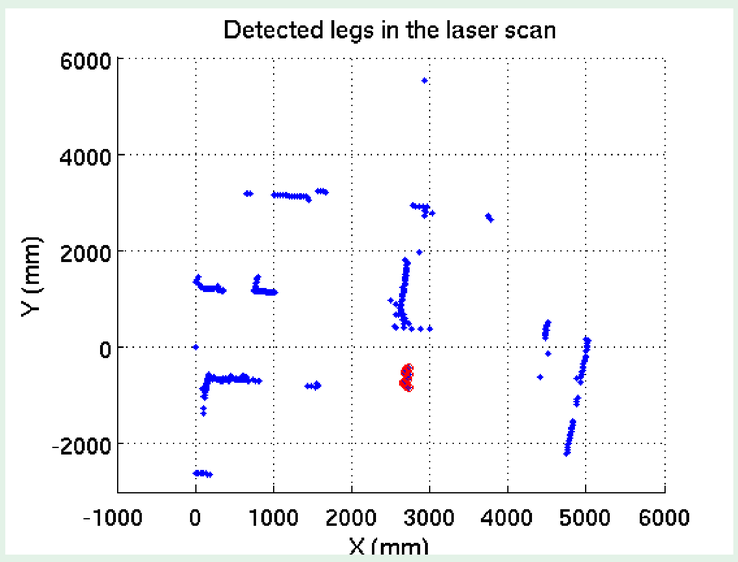
Dealing with a wide variety of experiments it is important to have a well designed software architecture too. This can reduce substantially the development time by ensuring code reuse and robustness in the software modules.



All layers have their test units defined. The adopted solution for unit tests is based on the test doubles, which act as the other packages during the test. This may be useful for larger projects to separate the testing for layers

People detection with LIDAR

A typical leg form described with a 3^{rd} order GMM is presented on the figure below.



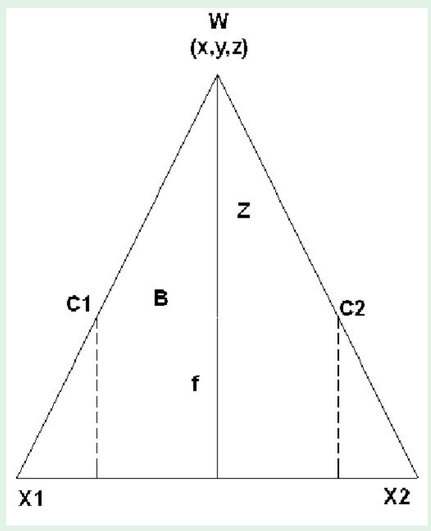
A specific shape can be described with the use of GMM model.

$$p(x|\Theta) = \sum_{m=1}^{M} \alpha_m p(x|\theta_m)$$

The Gaussian mixture parameters were determined with the expectation-maximization (EM) algorithm.

Stereo camera

A low cost option for 3D information acquisition is the use of stereo or multiple cameras. The reconstruction of the 3^{rd} dimension from multiple images can be expressed as follows.



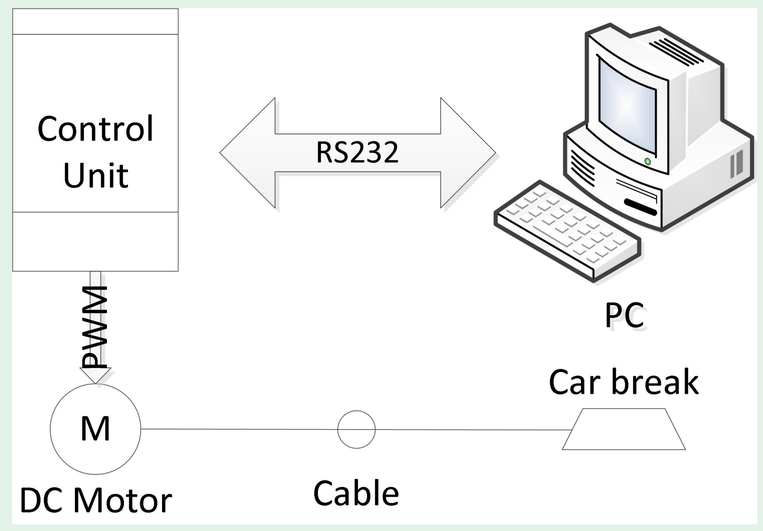
By simple geometrical deduction the depth information Z can be obtained in the following ways:

$$Z = \frac{fB}{x_1 + x_2}$$

where the absolute difference $d = |x_1 - x_2|$ represents the disparity, f is the focal length, B is the baseline, and X_1, X_2 represent the image coordinates in the right and left camera. The disparity can be defined as the difference between the coordinates of the same feature in the left and right image.

Custom active break assistant

The active breaking system was designed according to the Figure below. Its main purpose was to activate the breaking in the car in case that a pedestrian was detected.



Hardware components:

- PC
- control unit
- actuator motor
- link to the breaking system

The detection of the pedestrians is done based on the information from lidar and camera. The control unit is based on an microcontroller board which controls the DC motor with a PWM signal for activating the breaks. The link between the motor and the breaking system acts independently.

Experimental results

Two motion models for were adopted for people tracking. For both models the measured state variables were the people's position in the Cartesian coordination (x_k, y_k).

Position-velocity-heading model (PVH)

$$\begin{cases} x_k = x_{k-1} + \delta_k v_{k-1} cos\phi_{k-1} \\ y_k = y_{k-1} + \delta_k v_{k-1} sin\phi_{k-1} \\ \phi_k = \phi_{k-1} + n^{\phi}_{k-1} \\ v_k = v_{k-1} + n^{v}_{k-1} \end{cases}$$

Position-velocity-acceleration model (PVA)

$$x_k = \begin{bmatrix} 1 & \delta_k & \delta_k^2/2 \\ 0 & 1 & \delta_k \\ 0 & 0 & 1 \end{bmatrix} x_{k-1} + \begin{bmatrix} \delta_k^2/2 \\ \delta_k \\ 1 \end{bmatrix} n_{k-1}$$

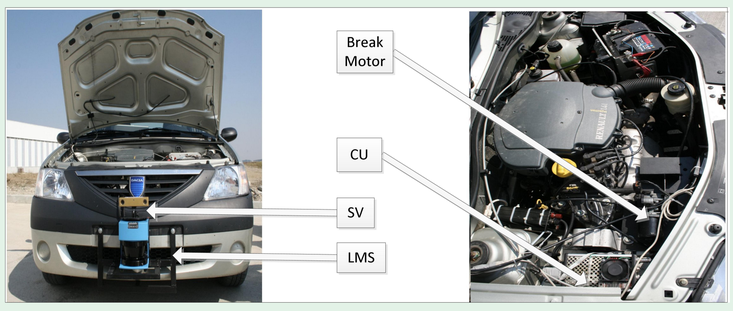
Motion Model Comparison for the Tracking

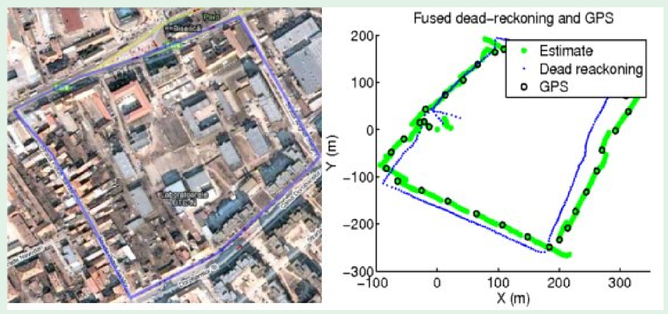
To compare the two models, the EKF was used to estimate the position of the detected person.

Criteria	PVH Model	PVA Model
Runtime (s)	6.2	7.9
$X_{Std}(cm)$	171	112
$Y_{Std}(cm)$	78	23

Experimental Results

Two outdoor experiments were performed for testing: one based on active break system on a commercial car for pedestrian tracking and one of self position tracking of a bicycle.





The test scenario was performed on normal road surface with a cruising speed of 30 $[km/h]$ and with the pedestrian crossing in front of the car at a $5[m]$ distance from the car. Between two consecutive

GPS readings, the DR can perform acceptable. Even if the data would be missing for a short period (e.g. tunnel without GPS availability), the DR still could give a reasonable position estimation.

Contact

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