An Integrated 4D Vision and Visualisation System

Distributed Events Analysis Research Laboratory &
Geometric Modelling and Computer Vision Laboratory
Institute for Computer Science and Control
Hungarian Academy of Sciences

Budapest, HUNGARY
http://sztaki.hu

Csaba Benedek, Zsolt Jankó,
Csaba Horváth, Dömötör Molnár,
Dmitry Chetverikov, Tamás Szirányi

{firstname.lastname}@sztaki.mta.hu
http://web.eee.sztaki.hu/i4d

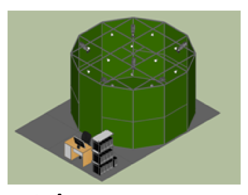
MTA SZTAKI

Overview

- System for reconstruction and visualisation of complex spatio-temporal scenes
- Integrates two different types of 4D data
  - outdoor data: multi-beam LIDAR sensor
  - models of moving actors: 4D studio
- Scenario: outdoor scene with walking pedestrians
  - LIDAR provides dynamic point cloud
  - 4D studio creates walking avatars
- Applications
  - 4D surveillance
  - video communication
  - augmented reality systems
- Patented *(Hungarian Patent Office 2013)*

Workflow

LIDAR data flow



Actor videos pre-recorded in a 4D studio

Foreground-background separation

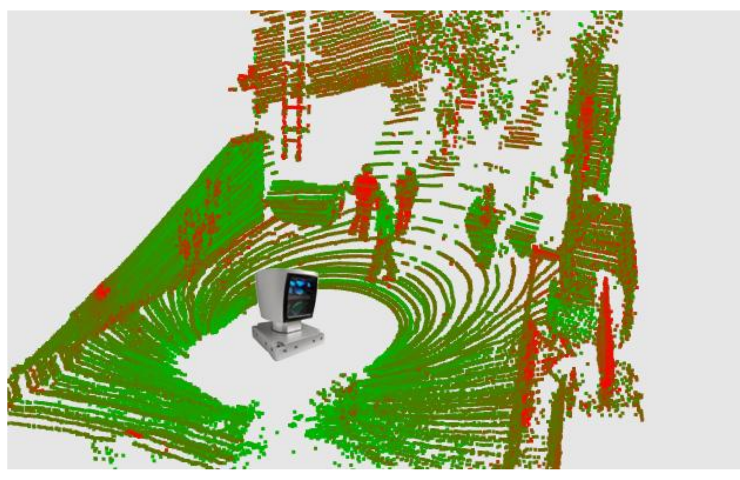
FG: Pedestrian detection & multi target tracking

BG: Environment reconstruction

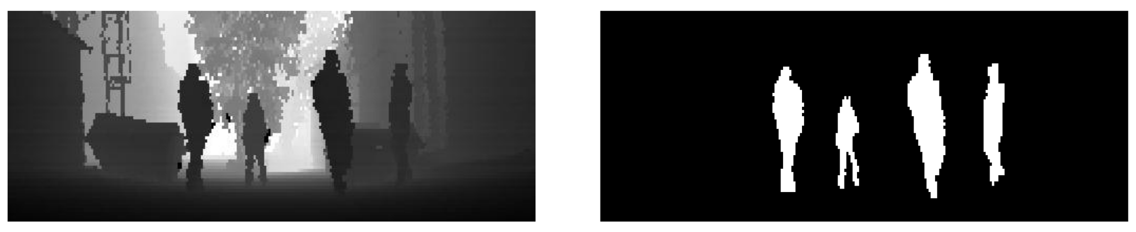
Building 4D models of walking pedestrian

Integration & visualisation of spatio-temporal scene model

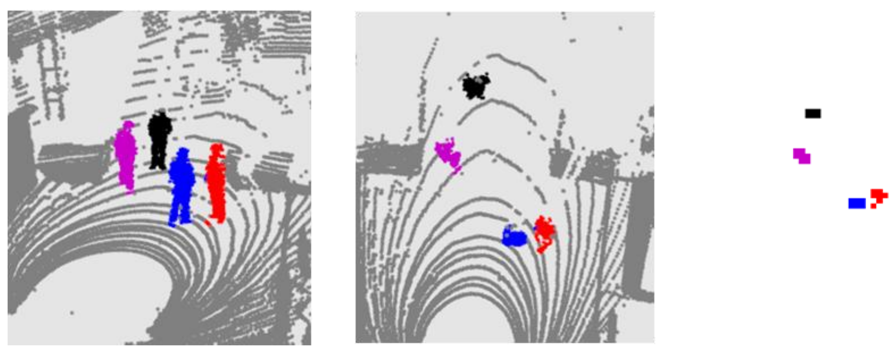
LIDAR Data Processing



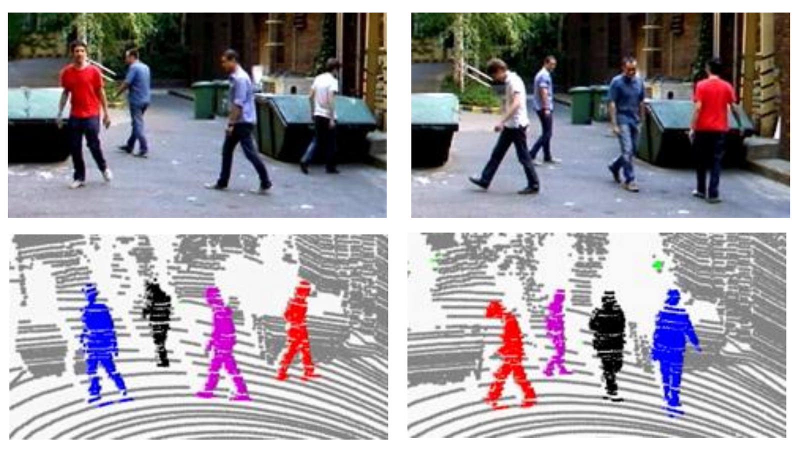
Input data in point cloud representation of a single time frame



Step 1: range image formation and foreground -background segmentation by a dynamic MRF model

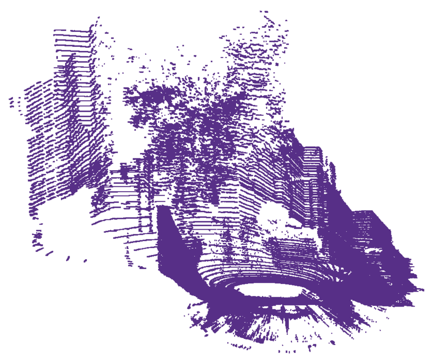


Step 2: pedestrian separation in foreground regions via ground projection and connected component analysis

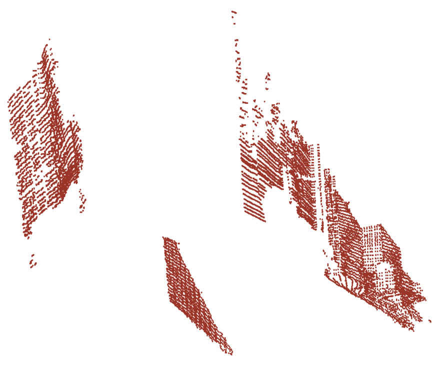


Step 3: pedestrian tracking by a Kalman filtering technique

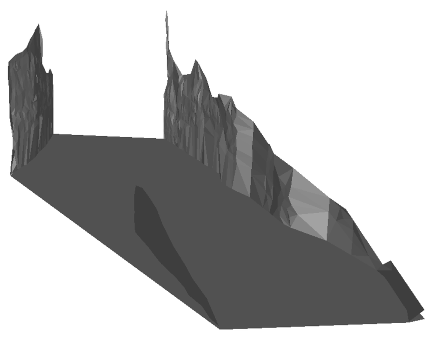
Environment Reconstruction



Step 1: merging the (static) background points over several frames



Step 2: wall filtering
•ground removal by RANSAC based plane fitting
•vegetation detection based on local statistical features (average point distance and irregularity)
•wall segmentation by line detection in a top-view projection (Hough transform)

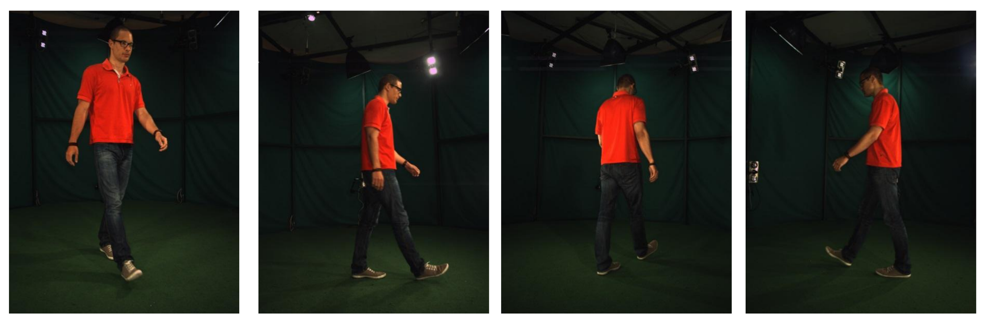


Step 3: ground plane insertion and wall triangulation with the Ball-Pivoting algorithm

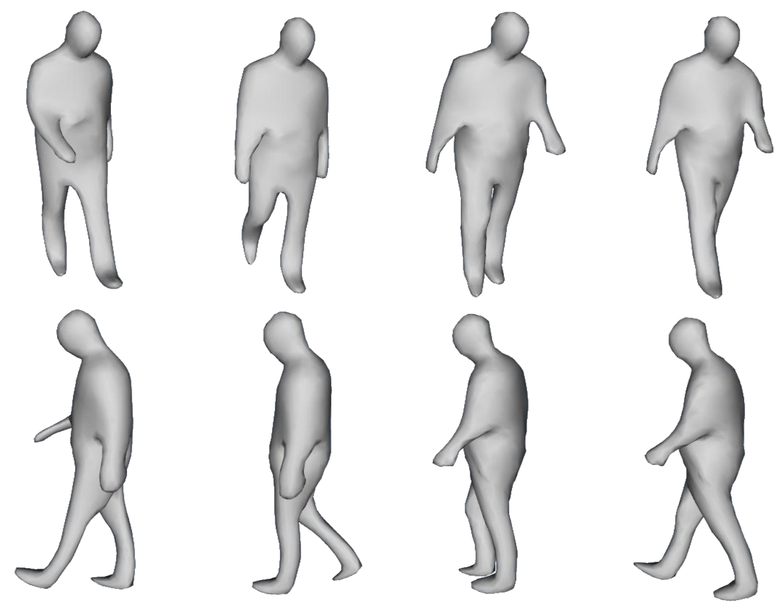
Step 4: complete background model synthesis by surface texturing and field object replacement with 3D models (trees, containers etc.)

4D Studio

Pedestrian visualization: creating textured moving pedestrian models in the 4D reconstruction studio



Camera inputs (4 out of 13 cameras)

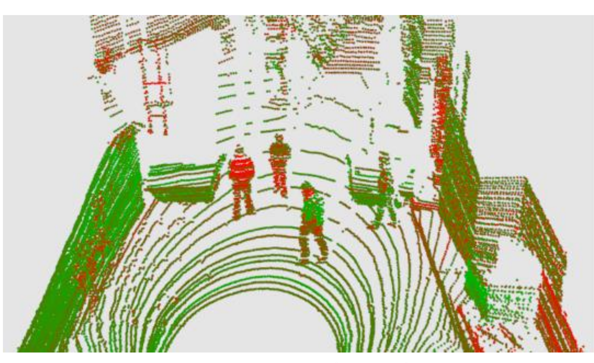


Step 1: reconstruction of 4D geometric models
•volumetric model synthesis of pedestrians by the Visual Hull algorithm
• triangulated mesh generation using the Marching Cubes algorithm

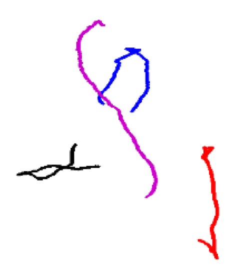
Step 2: model texturing and visualization

Integrating and visualising the spatio-temporal scene model

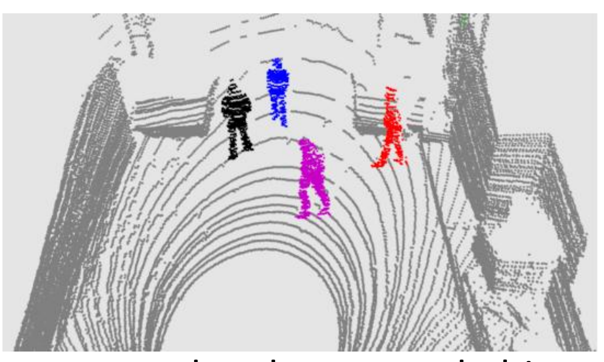
•Placing the walking pedestrian models into the reconstructed environment
•Moving the avatars according to the detected real trajectories
•Calculation of the top view person orientation from the variation of the 2D track
•Available models may be freely multiplied in space and time



raw point cloud



top view of trajectories



segmented and separated objects

avatars in reconstructed environment

Sample video frames with a simulated moving camera