Universität Bielefeld

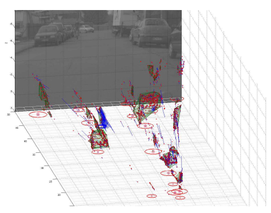
Object Independent Detection and Tracking in 6D

Niklas Beuter

Motivation

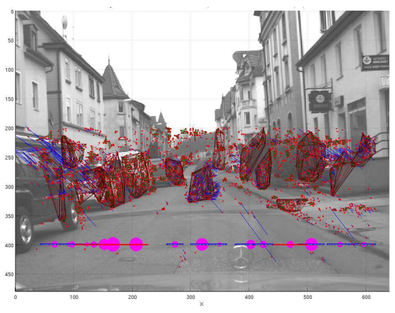
- Analyse a dynamic 3D scene to detect and track moving objects
- Information about the movement useful for cars or robots
  - Moving objects constrain the motion of the car / robot itself
  - Objects crossing the path could pose a threat
  - Movement of persons can be socially interpreted

$\Longrightarrow$ Utilising object trajectories to determine object movement

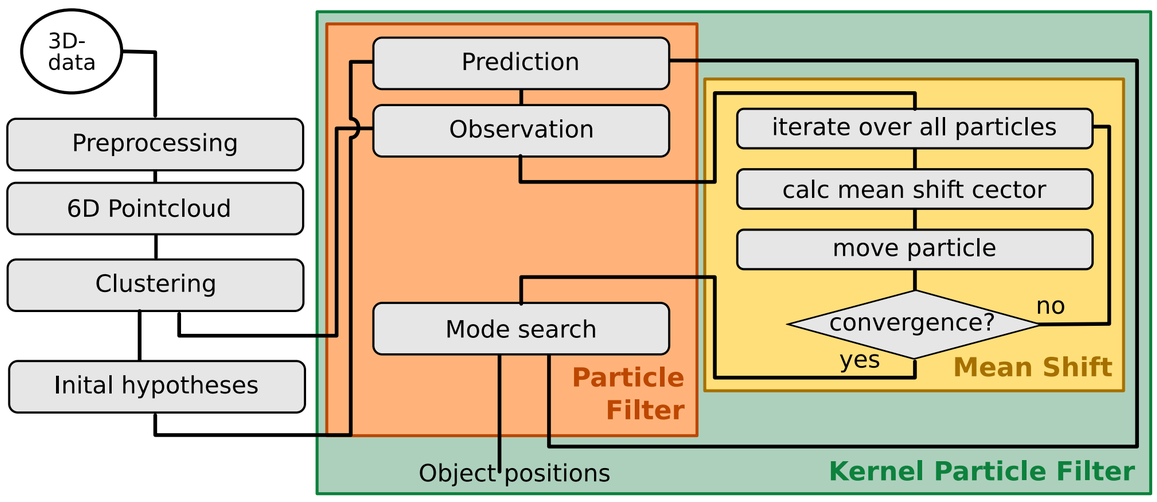


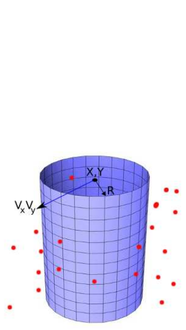
Main Idea

- Using 3D points extended with 3D velocities for better accuracy of discrimination
- Design an algorithm working on dense and sparse 6D information
  $\Rightarrow$ Using a stereo set-up or a 3D Time-of-Flight camera is possible
- Handle motion of camera itself
- Handle different types of objects, like cars or persons

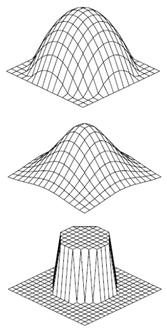


System Overview

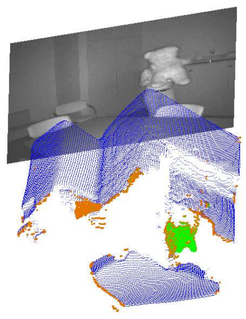




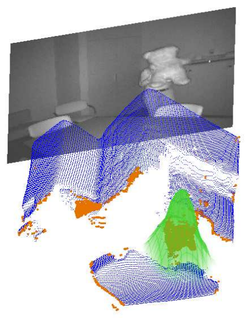
(a) Object model



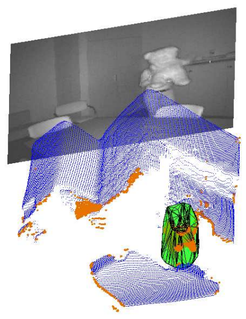
(b) Utilised kernel



(c) 6D points



(d) Observation function



(e) Detected Object

- Acquire 3D point cloud from sensor (Stereo or Swissranger)
- Preprocessing of the point cloud to delete outlier, calculate velocities and smooth the data
- Simplify Scene Representation by clustering and / or background subtraction to reduce computation time
- Detect Moving Objects using a weak object model (here: Cylinder with 5 Parameters: $\boldsymbol{o} = [x\ y\ v_\theta\ v_r\ r]^T$)
- Track Moving Objects using a kernel based particle filter
- Rate particles through an observation function $\rho(o_k)$:

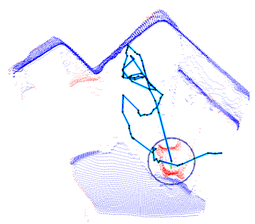
$$\rho(o_k) = K_r(o_k) \sum_{l \in o_k} K_d(l, o_k) K_v(l, o_k) \begin{cases} K_r(o_k) & = \exp\left(-\frac{r(o_k)^2}{2H^2_{r,\min}}\right) - \exp\left(-\frac{r(o_k)^2}{2H^2_{r,\max}}\right) \\ K_d(l, o_k) & = \exp\left(-\frac{\|d(l) - d(o_k)\|^2}{2\,H_d^2}\right) \\ K_v(l, o_k) & = \exp\left(-\frac{\|v(l) - v(o_k)\|^2}{2\,H_v^2}\right) \end{cases}$$

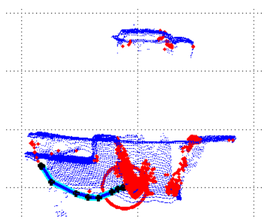
with: $\mathbf{K_r}$ = keeping radius in range, $\mathbf{K_d}$ = Masking out clusters further away, $\mathbf{K_v}$ = Masking out clusters with different velocities
$\boldsymbol{o_k}$ = object hypothesis, $\mathbf{l}$ = cluster, $\mathbf{H}$ = kernel width

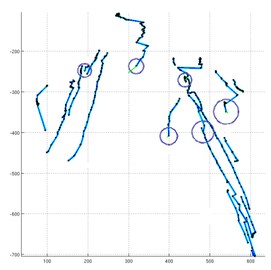
- Refine particle distribution through mean shift
- Search for objects by mode search
- Construct trajectories by tracking objects with an ID

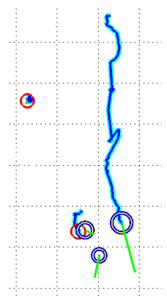
Results

- The evaluated scenes derive from a Swissranger installed on a mobile robot and from a stereo set-up in a moving vehicle*.
- The results show the accuracy of the proposed system to track on the one hand near objects like persons and on the other hand moving objects further away.









(* All indoor results have been established in cooperation with A. Swadzba, S. Wachsmuth and F. Kummert. All outdoor scenes and data are provided by DAIMLER research Ulm, Germany.)

http://aiweb.techfak.uni-bielefeld.de/user/nbeuter nbeuter@techfak.uni-bielefeld.de