Person Following Robot using Selected Online Ada-Boosting



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Centre for Vision Research

NCFRN NSERC Canadian Field Robotics Network RCCRT Réseau canadien CRSNG pour la robotique de terrain

*denotes equal contribution

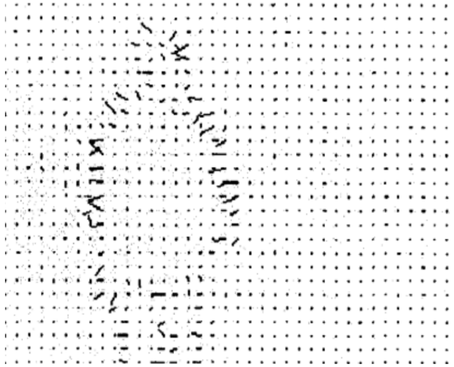
Introduction

- Robot follows the given target (human) in real time
- Problems addressed
  - Tracking
  - Navigation
- Challenges involved
  - Dynamic Environment: Occlusions (partial/complete), multiple humans in the scene
  - Algorithm needs to work in real time
  - Challenging situations: Pose changes, appearance changes, etc.
  - Smooth Robot Control

Pioneer 3AT Robot following a person

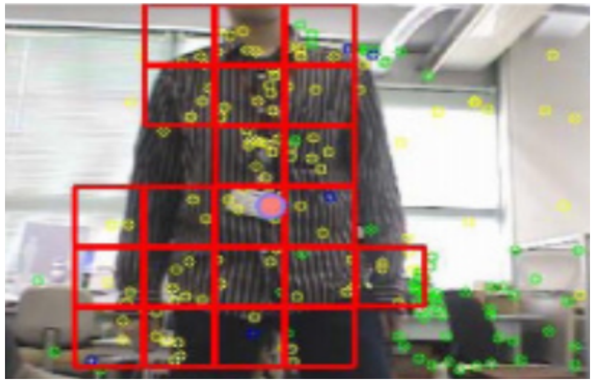
Relevant Work

Ku et al 1998
Shape and color.

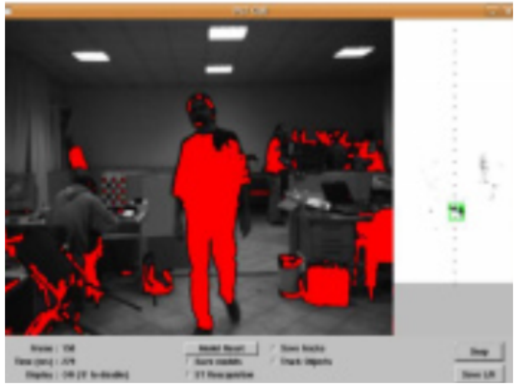


Piaggio et al. 1998
Optical flows for tracking

Tarokh et al. 2003
Shape and color from clothes



Yoshimi et al. 2006
Feature points with pre-registered color and texture



Calisi et al. 2007
Pre-trained appearance models

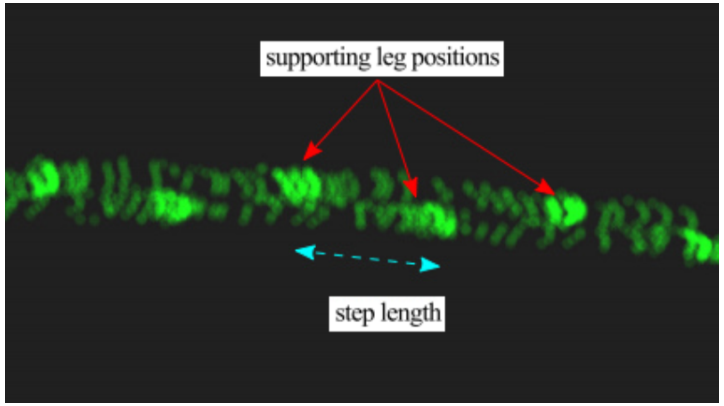
Chen et al. 2007
Sparse Lucas Kanade Features

Satake et al. 2009
Depth templates and SVM to train upper body classifier

Relevant Work

Tarokh et al. 2010
HSV and light variations

Satake et al. 2012
SIFT based identification



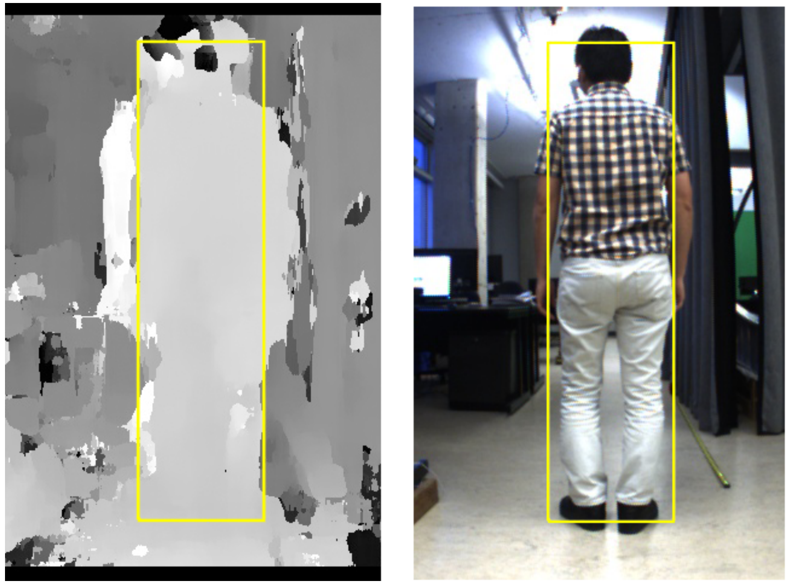
Koide et al. 2016
person identification using color, height and gait features

Our Approach

- A novel Selected Online Ada-Boosting (SOAB) Algorithm is proposed
- Build on top of Online Ada-Boosting using depth information
- Target object (e.g., human) needs to be known *a priori*
- Proposed system can be deployed on any mobile platform. E.g., Jackal, TurtleBot, Grizzly, Pioneer, VirtualME, etc

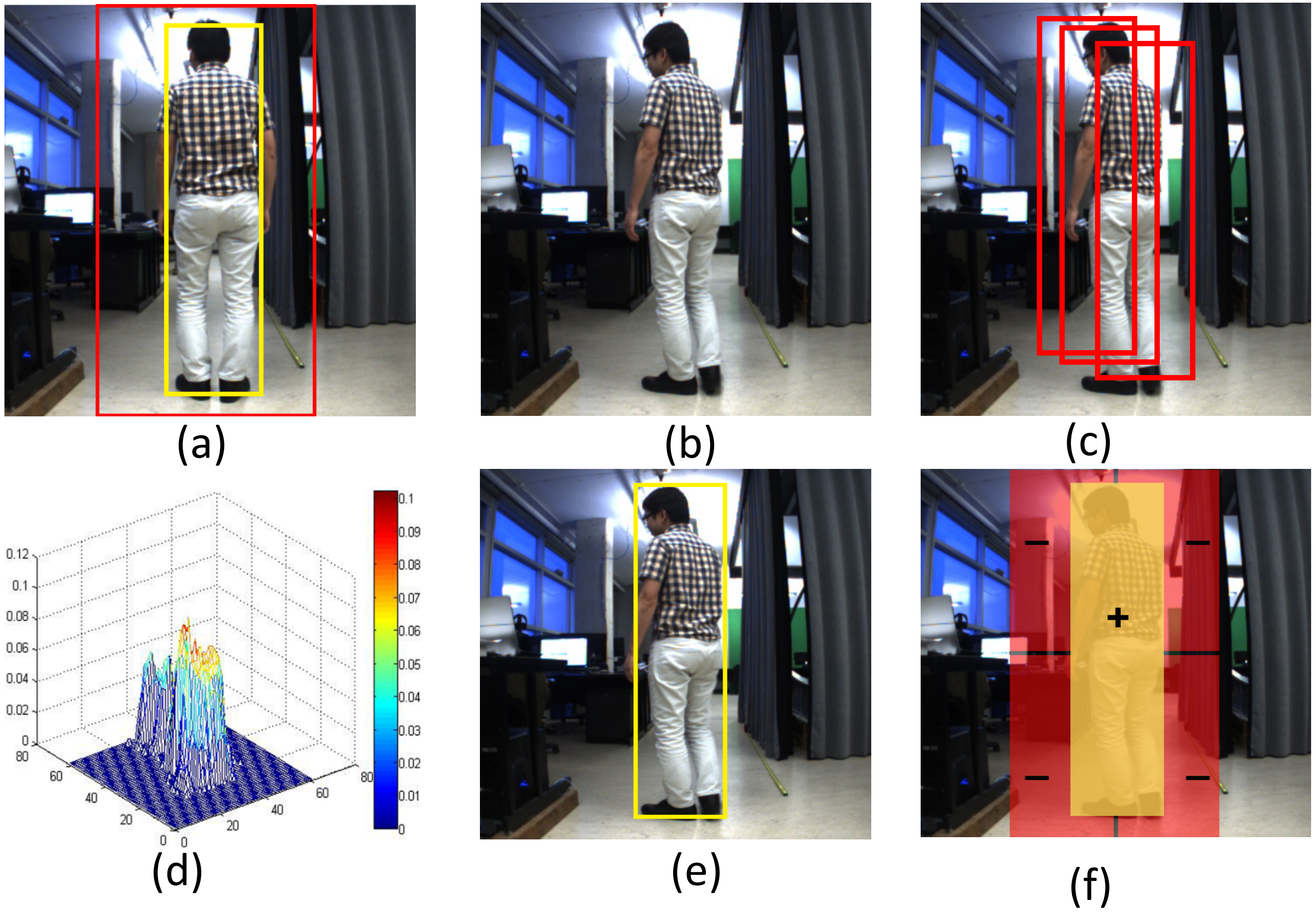
Our Approach

- Robot can track target in 2 ways: *user defined* or *pre-defined* bounding box
- *User defined:* user selects the target to be tracked
- *Pre-defined:* person stands at a pre-specified distance from the robot



Normalized disparity image & image from left camera

Online Ada-Boosting (OAB) Approach



OAB update process

(a) Yellow is target region, red box is the search region for the next frame

(b) Is the next frame

(c) Is searching and evaluating patches in the search region

(d) Is the confidence map of the evaluation

(e) Is the best matching patch with highest confidence

(f) Go back to (a) to search in the next frame.

*OAB [1] uses Haar and LBP features to build the model

[1] Grabner, H., Grabner, M. and Bischof, H., 2006, September. Real-time tracking via on-line boosting. In *Bmvc*, (Vol 1. No. 5, p. 6).

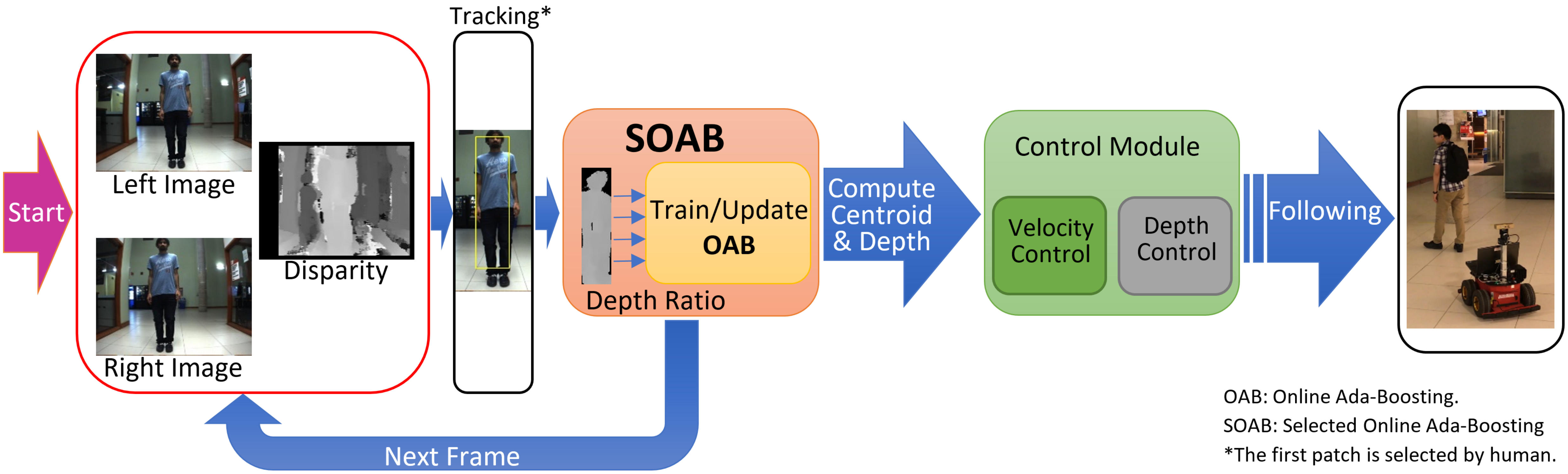
Our approach: SOAB Algorithm

Data: CameraStream
fetch left and right image from CameraStream;
select target to track;
calculate $curDisp$;
$preDisp \leftarrow curDisp$;
pre-train OAB;
while *true* **do**
  fetch left and right image from CameraStream;
  run OAB to extract a positive patch I_p;
  $curDisp \leftarrow Mean(I_p[I_p \in preDisp \pm \beta])$;
  $R \leftarrow \frac{\sum [I_p \in preDisp \pm \beta]}{w*h}$;
  if $R \geq \gamma$ **then**
    update the classifier;
  end
  $preDisp \leftarrow curDisp$;
end

Algorithm 1: SOAB

- β is the maximum displacement of the target
- R is the depth ratio
- γ is the depth ratio threshold

System Design



OAB: Online Ada-Boosting.
SOAB: Selected Online Ada-Boosting
*The first patch is selected by human.

Our Approach: Tracking module and the Navigation module

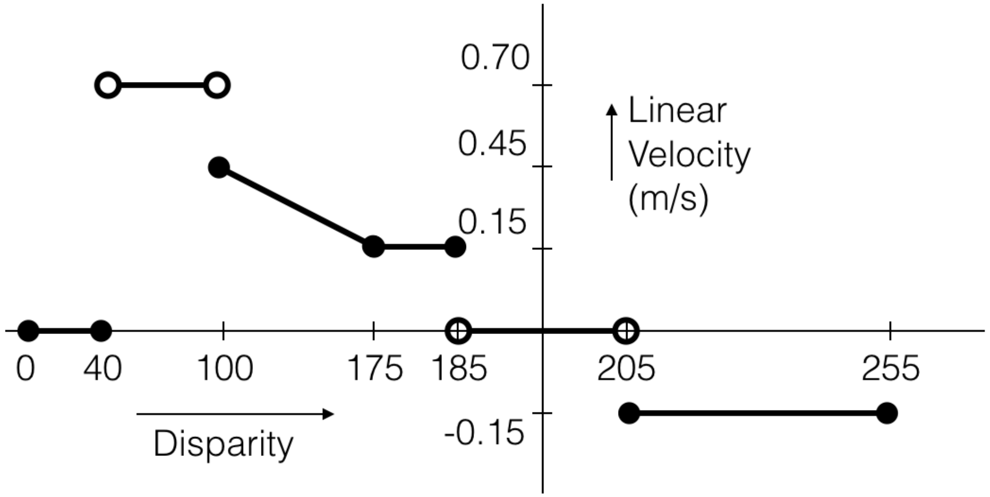
System Design

- A pioneer 3AT robot equipped with a Point Grey Bumblebee stereo camera is used.
- ROS is used to build the system
- System is run on a laptop with Intel core i7, 2nd Generation (2011), 2.5 GHz processor and 16GB RAM*

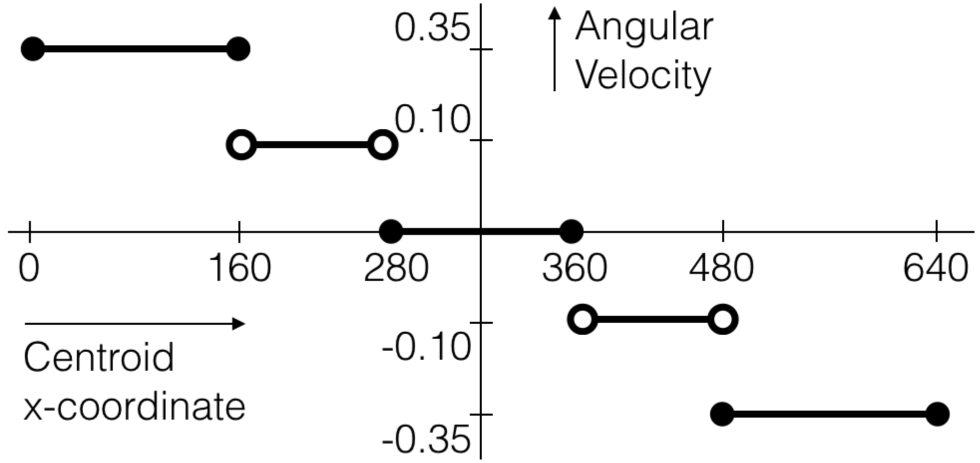
Pioneer 3AT Robot mounted with bumblebee camera

*(requirement is even lower for our algorithm)

Navigation Module



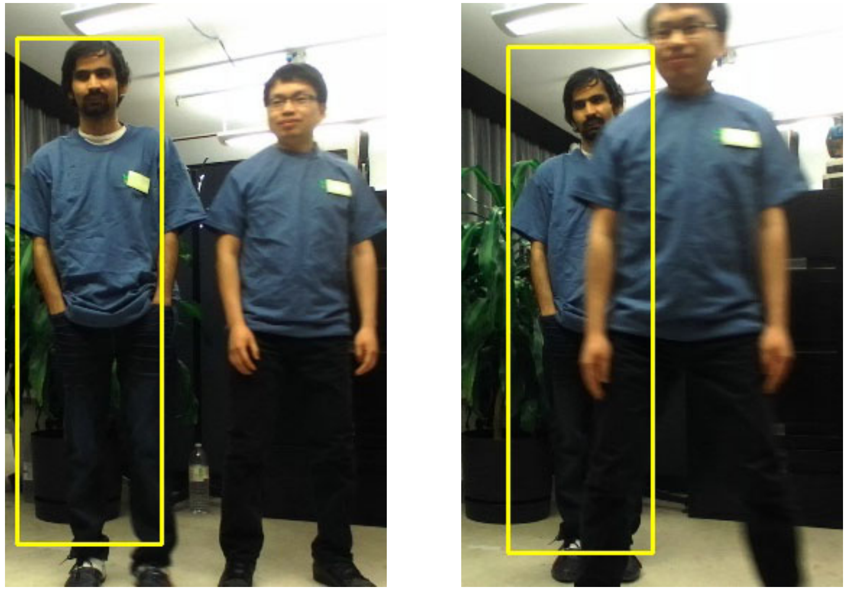
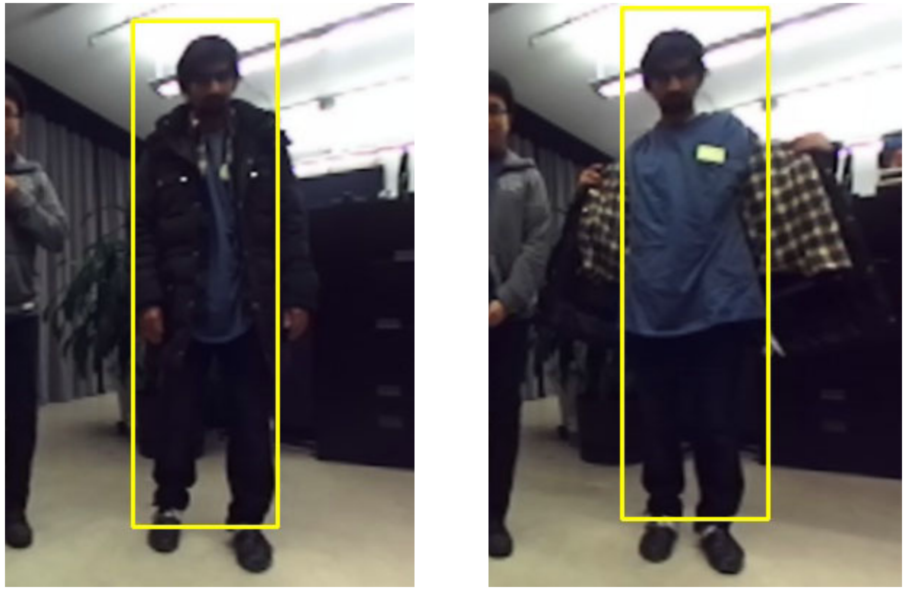
(a) Linear velocity as a function of the *depth* of the centroid



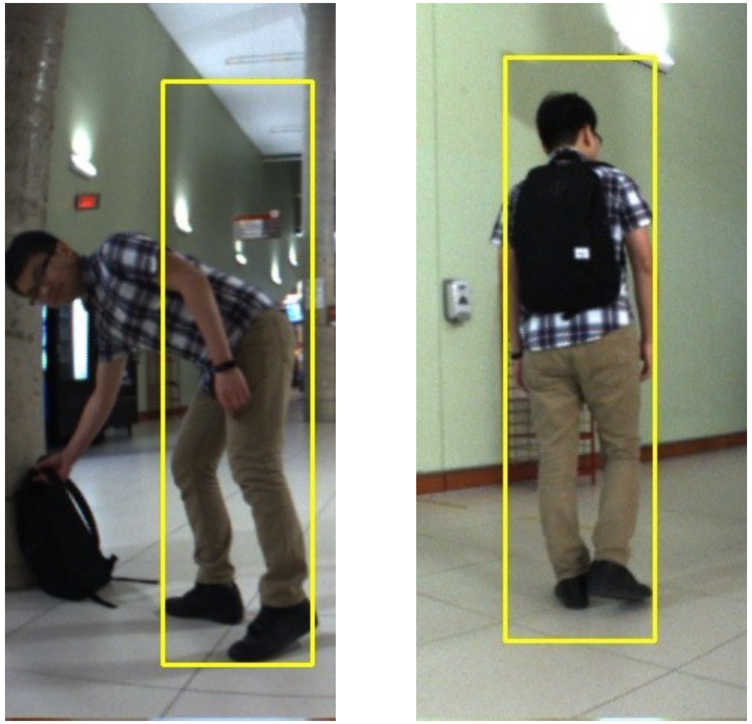
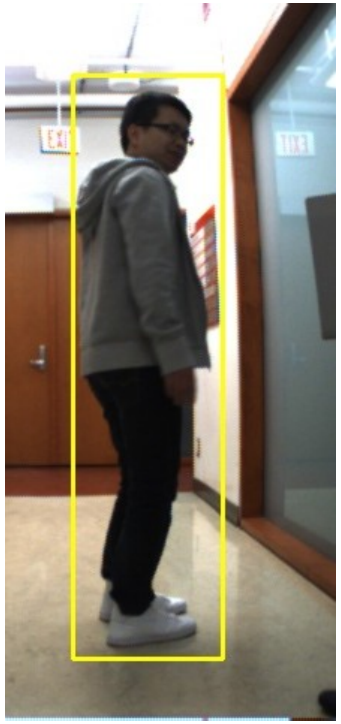
(b) Angular velocity as a function of the *x-coordinate of the centroid*

Controller Module of our system

Our Dataset: cases our approach can handle

		
People Wearing Similar Clothes under occlusions	Appearance changes Person removes his jacket	Partial and complete Occlusions

Our Dataset: cases our approach can handle

			
Picking up and bag	Sitting and crouching	Facing side to the robot	Illumination changes

Our Dataset

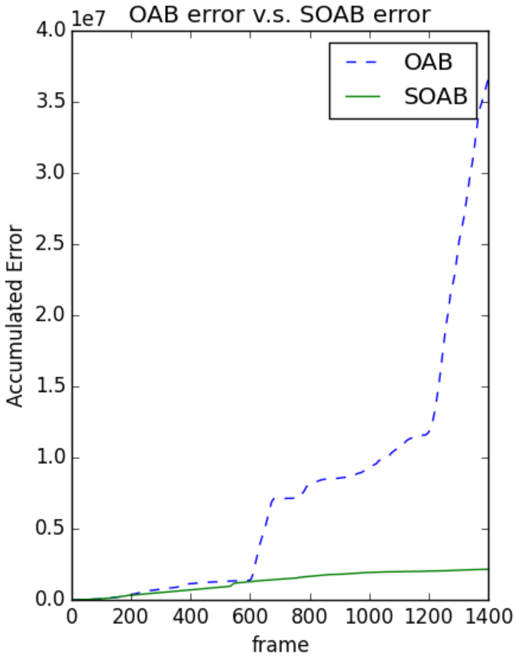
- A dataset of 4 image sequences is built in
  - University Hallway
  - Lecture Hall
  - Living room
- Available at http://jtl.lassonde.yorku.ca/2017/02/person-following/
- Frame rate: 15 fps at a resolution of 640x480.
- Camera used: Point Grey Bumblebee2 Stereo camera

Experiments and Evaluation

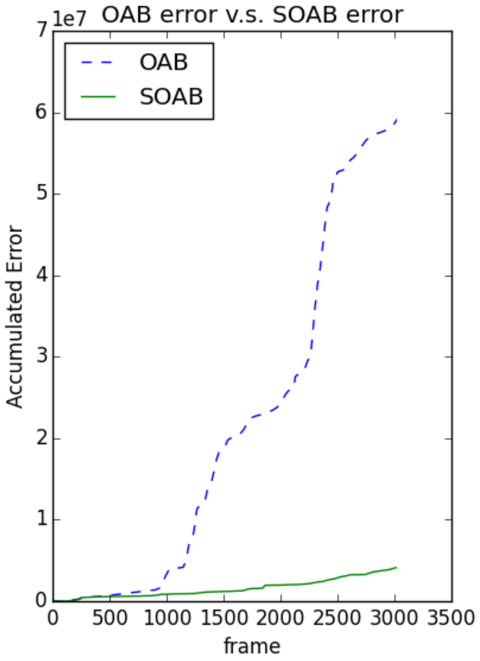
(a) (b) (c) (d) (e) (f) (g)
(h) (i) (j) (k) (l) (m) (n)
(o) (p) (q) (r) (s) (t) (u)

- (a-g) is tracking using original OAB algorithm.
- (h-n) is tracking using SOAB with depth ratio threshold γ = 0.30
- (o-u) is tracking using SOAB with with depth ratio threshold γ = 0.60

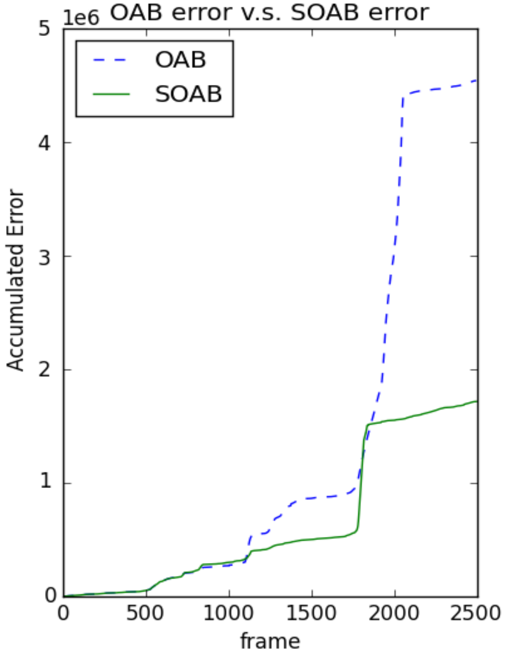
Experiments and Evaluation



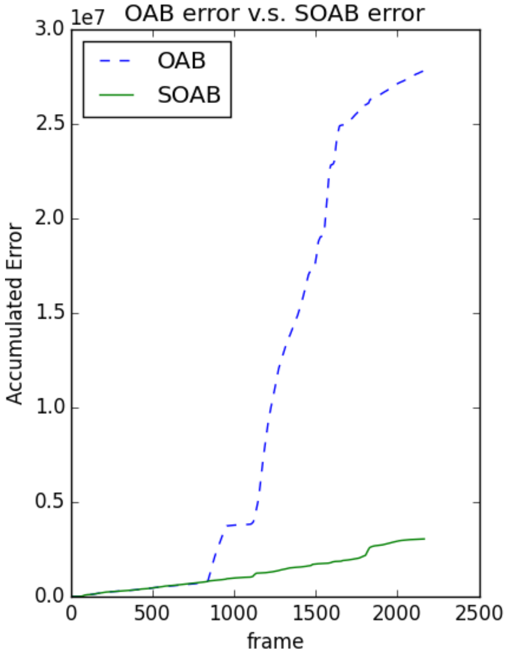
Multiple Crossings
Sequence



Hallway
Sequence



Lecture Hall
Sequence



Same Clothes
Crossing Sequence

<u>Accumulated Squared error from the centroid of the ground truth .</u>

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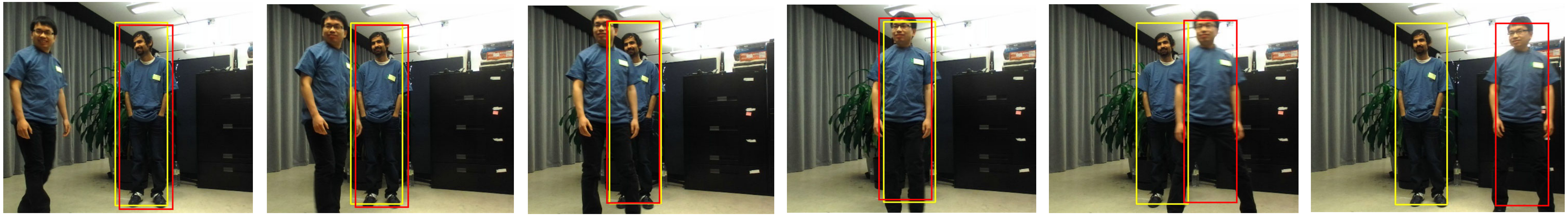
Experimental Results

Hall way Sequence



Same clothes crossings sequence

Yellow Box shows our approach (SOAB) and Red box shows OAB approach.

OAB looses the target under occlusions in both cases

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Experimental Results

Lecture Hall sequence

Yellow Box shows our approach (SOAB) and Red box shows OAB approach.

OAB looses the target under occlusions in both cases

Conclusion

- A novel Selected Online Ada-Boosting Approach was presented
- Approach generalizes to any object following robot not just humans
- Handles challenging cases and is robust
  - Appearance/pose changes
  - Occlusions
  - People wearing similar clothes
- Demo Video: http://jtl.lassonde.yorku.ca/2017/02/person-following/

Future Work

- Using CNNTracker instead of the Ada-Boosting approach
- Using human detection approaches as a filter to prune out the search space for updating the classifier
- Incorporate mapping into the scene to avoid obstacles and do path planning

Acknowledgements

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