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Autonomous Person Following For Tele-presence Robots

Akansel Cosgun, Dinei Florencio, Henrik I. Christensen

Robotics@GT & Intelligent Machines

Autonomous Person Following for Telepresence Robots

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- Considers interaction between remote user and followed person
- Task-specific goal function maps desirable places around person (as opposed to a goal position)
- Human motion is predicted, future trajectories of robot are simulated
- User study: our autonomous person following vs manual teleop
- Auto mode reduces cognitive load, found natural and safer
- All 10 remote users chose our auto following over joystick control
- Interesting design considerations for telepresence robots

Abstract—We present a method for a mobile robot to follow a person autonomously where there is an interaction between the robot and human during following. The planner takes into account the predicted trajectory of the human and searches future trajectories of the robot for the path with the highest utility. Contrary to traditional motion planning, instead of determining goal points close to the person, we introduce a task dependent goal function which provides a map of desirable areas for the robot to be at, with respect to the person. The planning framework is flexible and allows encoding of different social situations with the help of the goal function. We implemented our approach on a telepresence robot and conducted a controlled user study to evaluate the experiences of the users on the remote end of the telepresence robot. The user study compares manual teleoperation to our autonomous method for following a person while having a conversation. By designing a behavior specific to a flat screen telepresence robot, we show that the person following behavior is perceived as safe and socially acceptable by remote users. All 10 participants preferred our autonomous following method over manual teleoperation.

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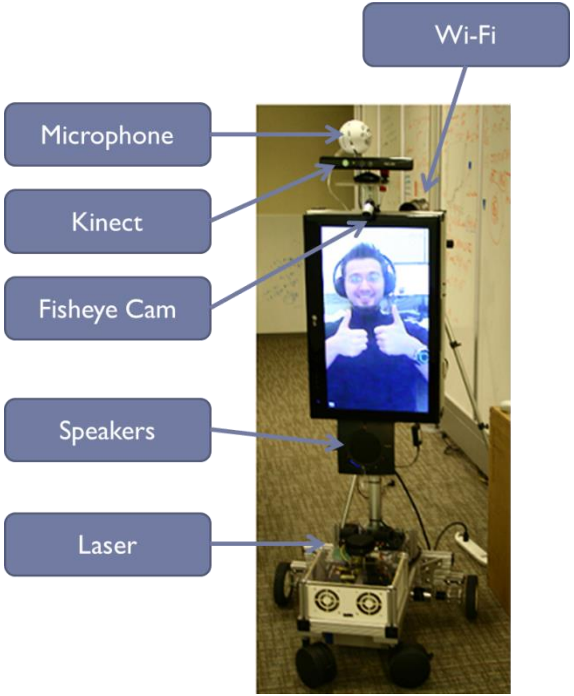
Prototype



"Skype on Wheels"

Operation Modes

- 1. Manual Teleoperation

- 2. Assisted Driving

+ Guidance & Obstacle Avoidance

[IROS'2012]

- 3. *Supervised* Autonomous Driving

"Follow a Person"

this paper!

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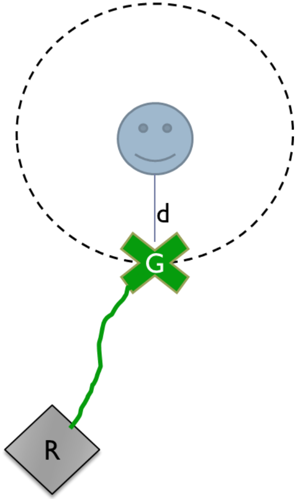
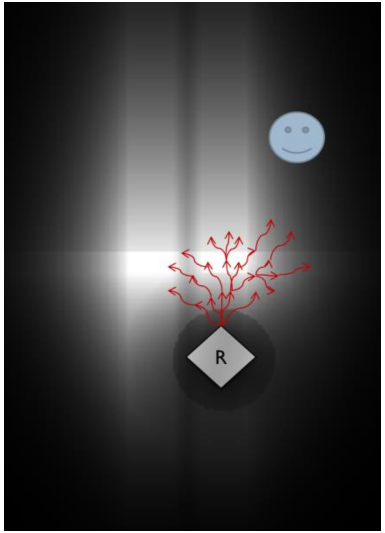
Following – Traditional Approach



- **Fixed goal** w.r.t person.
- Plans is complete for now, but the goal will change in next frame
- Interaction w/ robot not considered

Following - Our Approach



- A robot-centric utility function
  - Plan to earn max utility in next T seconds
  - Social navigation can be encoded
  - Task dependent
- Following behavior:
  - Person can see the screen: Keeps person in 2 lanes, front/front-left.
  - Motions are Predictable: Changing lanes are discouraged
  - Personal Space: Getting too close to person discouraged

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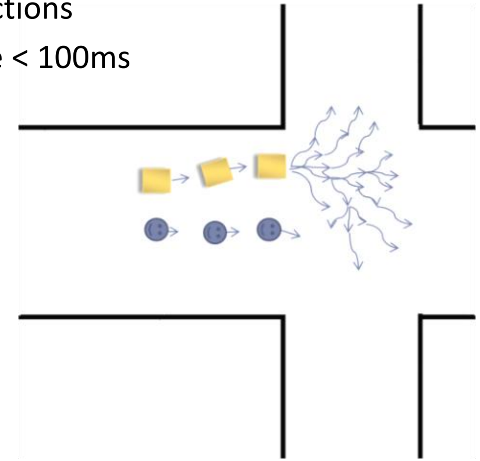
Following – Our Approach (2)

- Predicts human motion (Constant Velocity model)
- Plans future T seconds
- Depth limited Breadth First Search
- Maximize discounted Utility
- U= f(person, obstacles, acceleration)
- Evaluates ~10000 trajectories
- 70 discrete actions
- Planning time < 100ms



Person Tracking

- Laser Scanner: 360˚ FOV @5Hz
- Leg detection w/ 3 geometric feats
- Trained on ~17,000 leg measurements:

	Width(m)		Circularity		IAV(rad)	
Pattern	μ	σ^2	μ	σ^2	μ	σ^2
Single Leg	0.13	0.03	0.25	0.15	2.23	0.40

- Mahalanobis dist for all segments in scan
- Nearest neighbor matching

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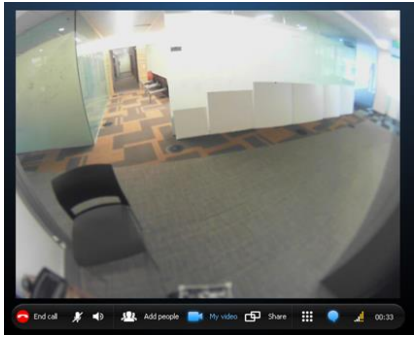
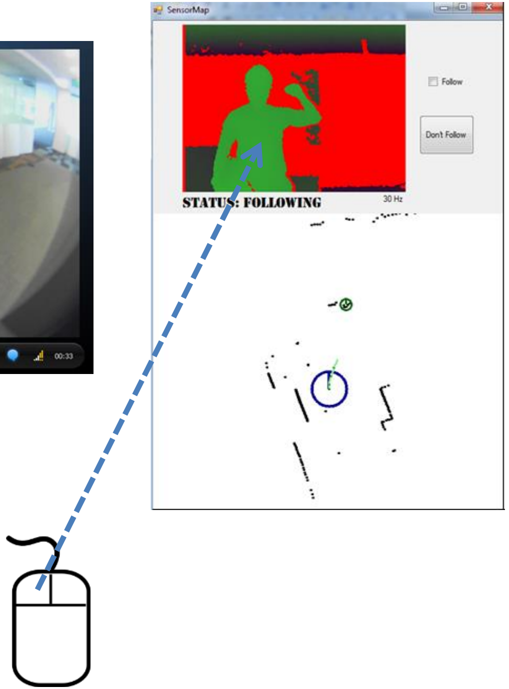
GUI –Remote End





(video here)

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User Study (N=10)

- Evaluate Remote User experience
- Robot and Person walking in corridor
  - Case 1: Manual Tele-operation
  - Case 2: Auto Person Following
- Followed person reads a passage (2 example TOEFL reading part)
- Measures:
  - 4 questions after each passage
  - Questionnaire on usability
  - Method of choice

User Study Results (N=10)

- TOEFL passages (4 questions):
  - Manual: (M=2.2, SD=1.2)
  - Auto: (M=2.9, SD=0.9)

	Autonomous		Manual		*t*-test	
Question	μ	σ	μ	σ	p	t
1. Understandable	4.0	1.5	3.6	1.7	0.47	0.73
2. Easy UI	6.5	0.9	5.0	2.2	0.06	2.13
3. Natural motion	5.4	1.0	3.5	1.9	0.03	2.52
4. Safety	5.1	1.7	2.3	1.4	0.01	3.09
5. Pay attention	5.3	1.8	3.4	1.5	0.02	2.63
6. Fast	3.9	0.3	4.3	0.8	0.10	-1.80
7. Fun	5.3	1.5	5.1	1.7	0.66	0.45

- 10/10 preferred Autonomous Following over Manual Tele-operation.

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Design Implications

- Motor Noise: 8/10 said motor noise is problematic
  - *"When I was driving, it was always this constant sound."*
  - *"I actually like it because it gives me feedback whether I am driving fast or slow"*
- Wi-Fi: Connection problems are a big problem
  - *"The frame rate drops all of a sudden and you have no choice but to stop."*
- Assisted Tele-operation
  - *"Maybe something like a cruise control might be good."*
- Gaming: Less trouble driving the robot
  - *"Manual is like playing video games"*
- Long Term Interaction: Long term studies can be useful
  - *"If I have more practice for several hrs, I can use manual as well as autonomous"*
- Error Recovery: Subject didn't complain when robot lost person
  - *"That's not a big deal in comparison to me driving the robot"*

Conclusions

- New path-based criteria for path-planning
- Autonomous Person Following is useful for Tele-presence robots
- Added autonomy reduces cognitive load
- Remote users trust and like added autonomy
- Human-in-the-loop control compensates for robot errors
- More to explore in Tele-presence

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