EyeWalker
Ultralight low-cost vision system for mobility aids

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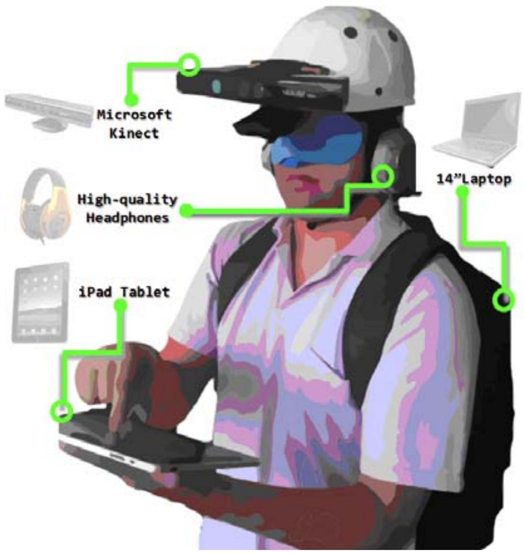
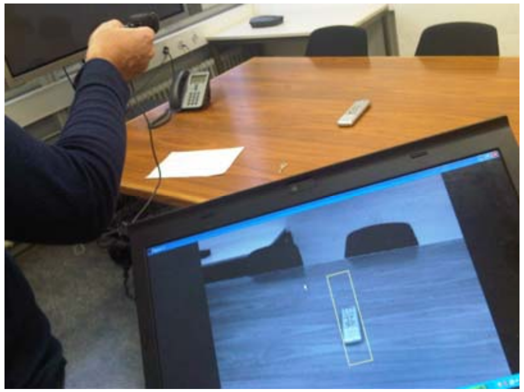
Presentation

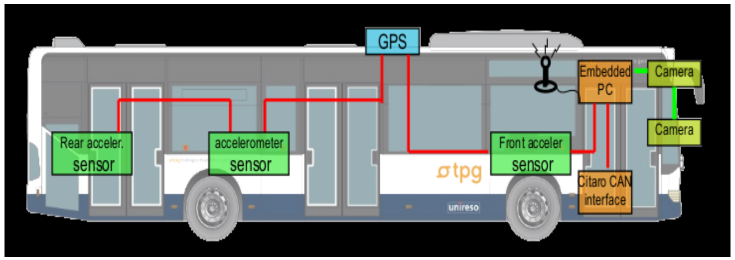
Multimodal interaction and handicap:





Presentation

Affective computing:



Outline

- Context and goals
- Workplan and evaluation
- WP1: User's requirements
- WP4: Hardware setup
- WP2: Obstacles detection
- WP3: Ground changes detection
- Conclusions and future work

Context

Context:

- increasing senior population;
- mobility problems: health-related, sensory disabilities;
- 1/3 of the population aged over 65 years falls at least once per year (50% for people over 80 years).

Millions use rollators... But rollators might fail to help or even contribute to an accident:

- indoors and outdoors;
- in familiar and unfamiliar environments.

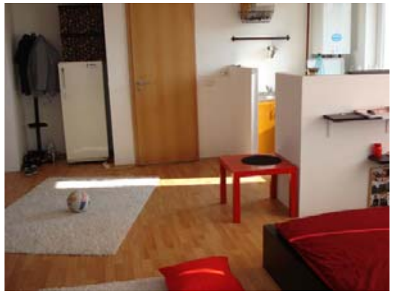
General aim: favor independant living of the elderly.

Context

Problematic situations, indoors and outdoors, when user:

- misjudges nature or extent of obstacles: cluttered environments, surface change, narrow passage;
- does not perceive the obstacle: lateral or at floor level, because of sensory handicap (visual or auditory).

Examples:




Goals of Eyewalker

To develop a very low-cost, ultralight vision system, as independent accessory to be “clipped” on a standard walker.

Vision system:

- no "general" computer vision;
- only typical obstacles from user requirements analysis.

Unobtrusive visual and/or auditory output (+ vibrating handles?).

Constraints on the device:

- light, sturdy, easy to setup (e.g. by family);
- real-time and autonomous processing, long autonomy (day);
- indoor and outdoor (high light dynamic range);
- cost.

Going beyond the state-of-the-art

Compared to current prototypes we want:

- no motorization, no active sensing (laser, sonar, IR) or landmark-based sensing (RFID tags, visual signs);
- no complex software for route planning and scene analysis;
- low cost, accepted by users at large (end-user, caretakers);
- low weight (for easy transportation), autonomy.

Research questions:

- is sparse 3D sensing enough?
- how to infer behavior from frontal cameras?
- how to learn from past actions, environment, and how to adapt?
- minimal number of sensors?

... all this in real-time, with high autonomy.

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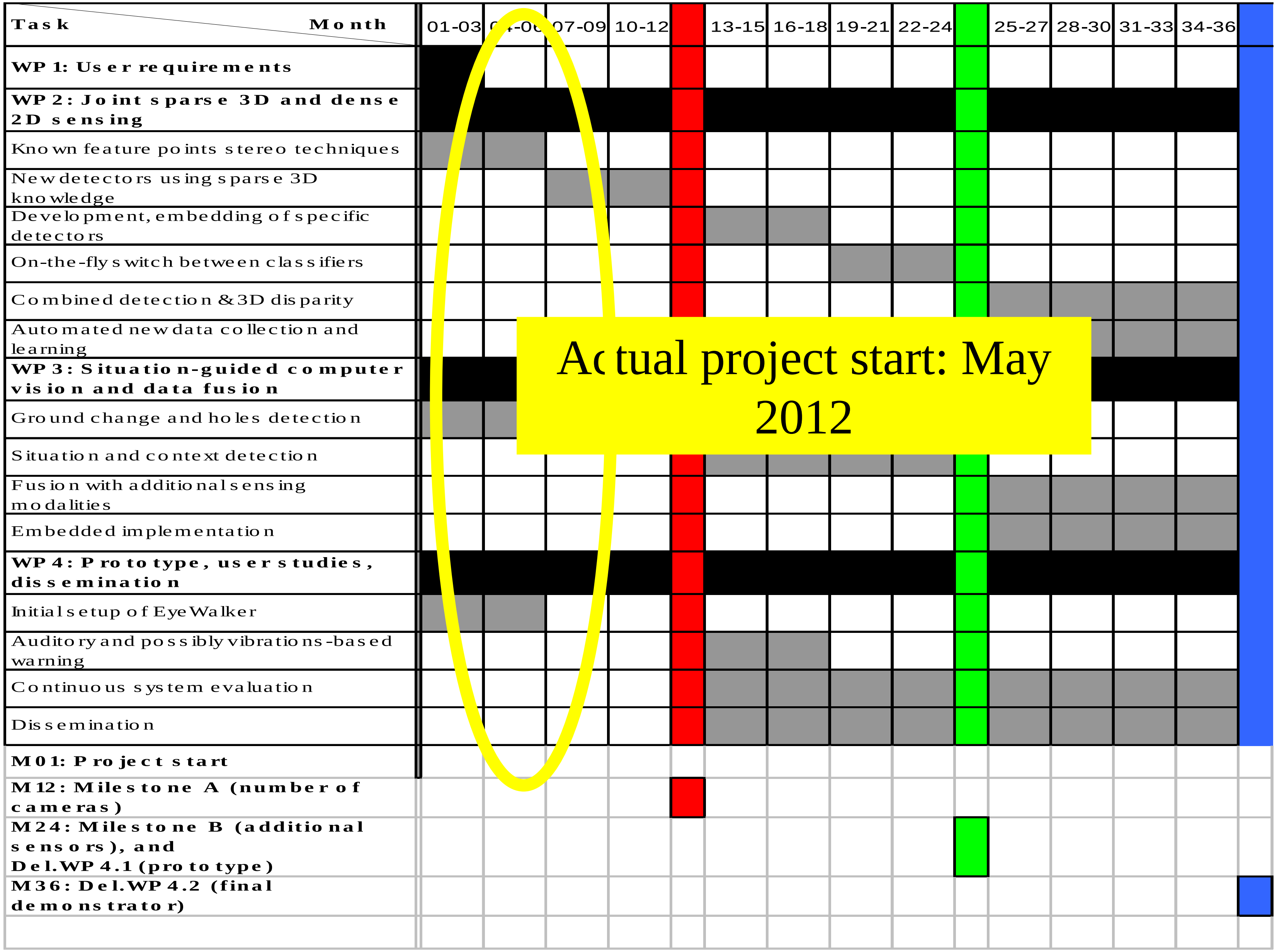
Workplan


Task
Month
01-03
07-09
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
WP 1: User requirements
WP 2: Joint sparse 3D and dense 2D sensing
Known feature points stereo techniques
New detectors using sparse 3D knowledge
Development, embedding of specific detectors
On-the-fly switch between classifiers
Combined detection & 3D disparity
Automated new data collection and learning
WP 3: Situation-guided computer vision and data fusion
Ground change and holes detection
Situation and context detection
Fusion with additional sensing modalities
Embedded implementation
WP 4: Prototype, user studies, dissemination
Initial setup of EyeWalker
Auditory and possibly vibrations-based warning
Continuous system evaluation
Dissemination
M01: Project start
M12: Milestone A (number of cameras)
M24: Milestone B (additional sensors), and Del.WP 4.1 (prototype)
M36: Del.WP 4.2 (final demonstrator)
Actual project start: May 2012

Evaluation

Technical evaluation:

- error rates on typical use cases, and on public benchmarks if available (eg. EvAAL);
- computational complexity, speed, energy consumption.

Prototype evaluation:

- quantitative displacement indicators: speed, balance, distance travelled autonomously from A to B without/with the system;
- training time;
- users' experience: usability and ergonomics, acceptance and satisfaction.

Training and experiments with users under total supervision.

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Users' requirements

Based on series of interviews with ergotherapists, psychologists, end users: FSASD (Geneva), EMS-Charmilles (Geneva), Foundation «Tulita» (Bogota, Colombia).

Target users: elderly persons that still live relatively independently.

Requirements:

- detection of 3 categories of obstacles (see next);
- prevent bad use of the walker;
- predict when a user is going to fall back;
- determine behavior (trajectory, affective state);
- correction of the route of the user (spatial position);
- help to explore the unfamiliar areas.

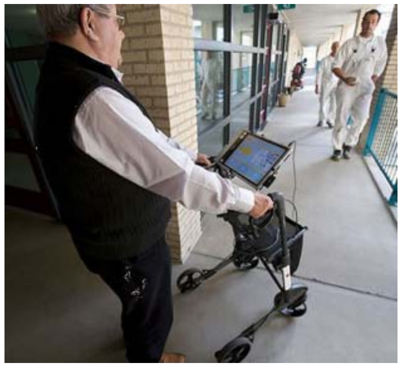
Users' requirements

Detection of obstacles at 3 levels as seen from the user:

- ground level : change of terrain, rug/carpet, holes;
- mid-level: chairs, tables, small obstacles;
- high level: walls, doors, people, hanging objects.






Users' requirements

Typical scenario:

- system installation and simple optical calibration;
- training, displacement in environment with aid (family, caretaker) to indicate:
  - typical dangerous situations;
  - landmark objects;
- usage, with system learning:
  - other views of situations and objects;
  - rough environment map;
  - user's typical behavior;
- in case of problem:
  - warning to ***user***, as inconspicuous as feasible;
  - to be decided: panic button (e.g. if camera views change quickly).

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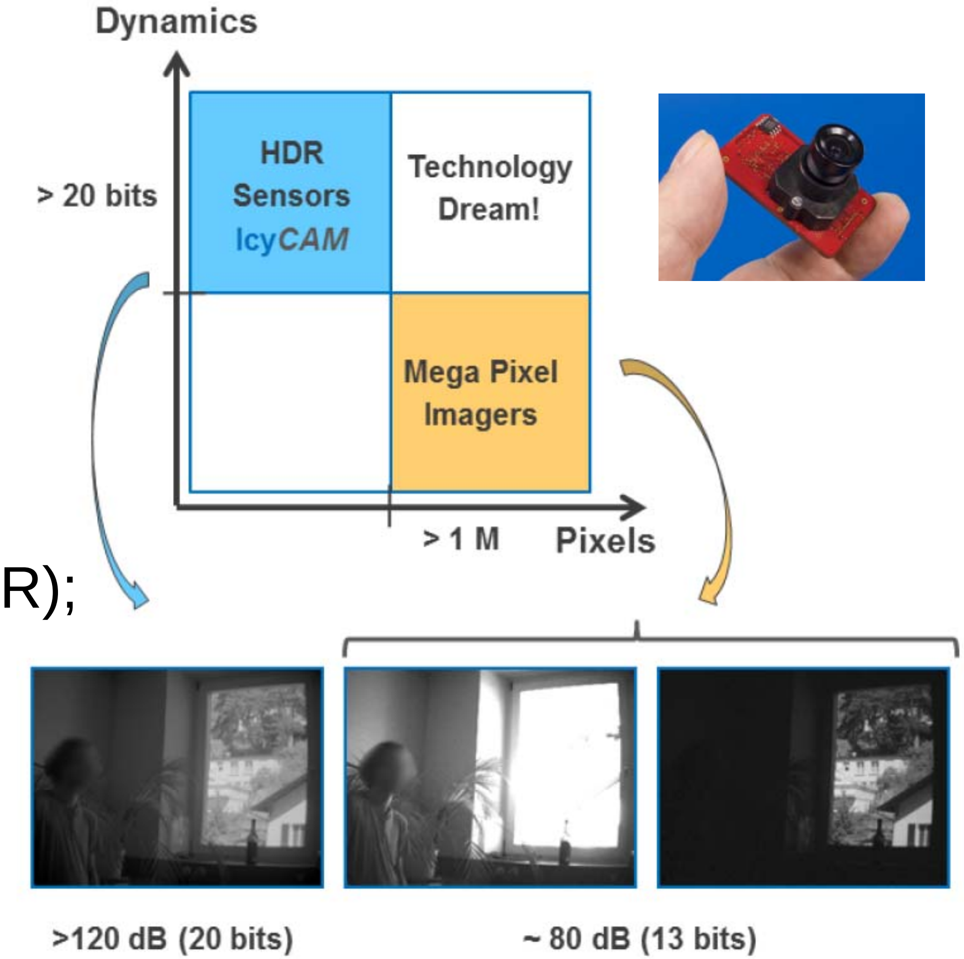
Hardware setup: Icycam (CSEM)

Characteristics:

- gray-level;
- resolution: 320x240 pixels;
- power consumption:
  0.4W at 3.3V;
- cost: CHF 2000 to 10.

Advantages:

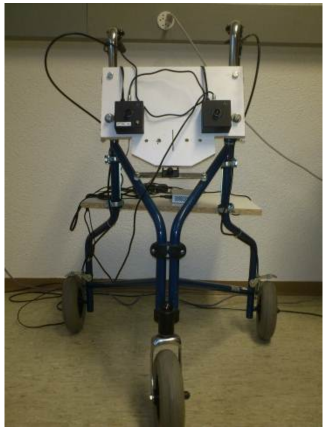
- very high dynamic range (HDR);
- suited for large uncontrolled light changes;
- fast response.

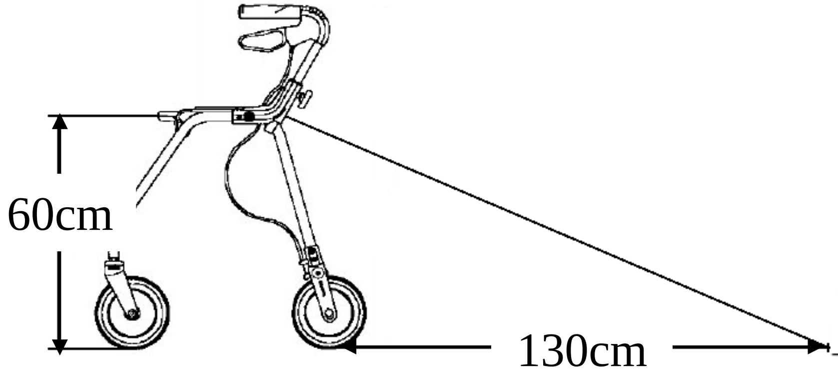


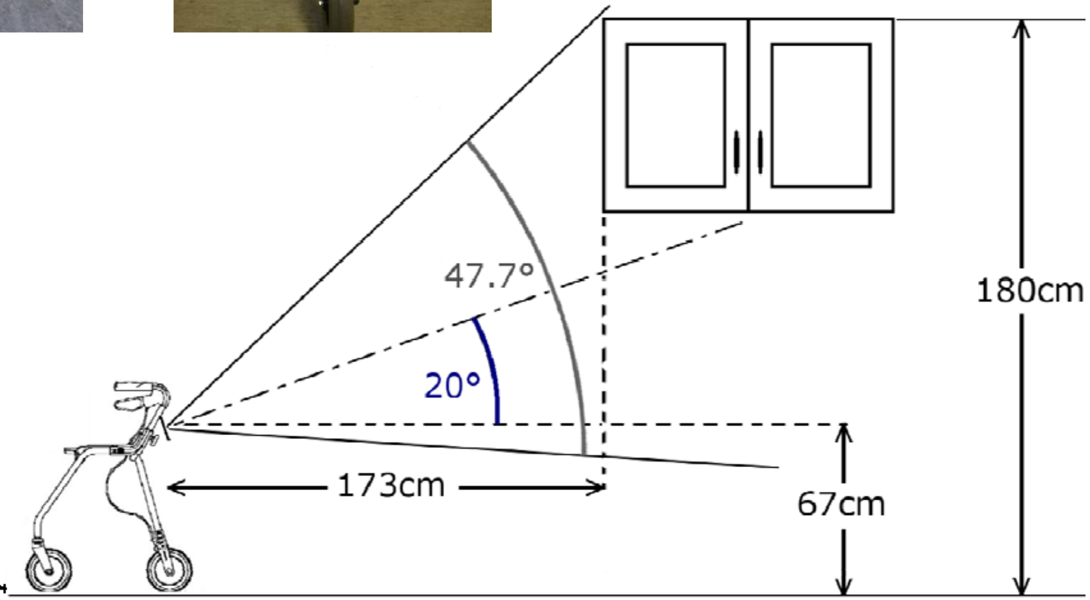
Hardware setup: experimental rollators

With PC and webcam

IcyCam stereo rig





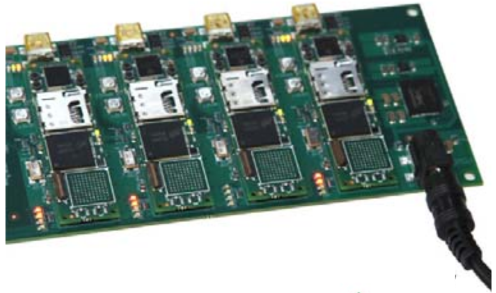


Hardware setup: development platform

Goal: day-long autonomy, off-the-shelf HW.

Gumstix® products:

- Overo® water- and fireSTORM;
- Stagecoach® expansion board;
- Yocto project for customized light linux distribution.



Current configuration:

- 1 stick per camera (clock synchronisation via NTP, 1 master – 2 slaves);
- standalone local network.

Voltaic V60 battery:

- 60Wh, 16Ah: 3 to 6 hours life time.

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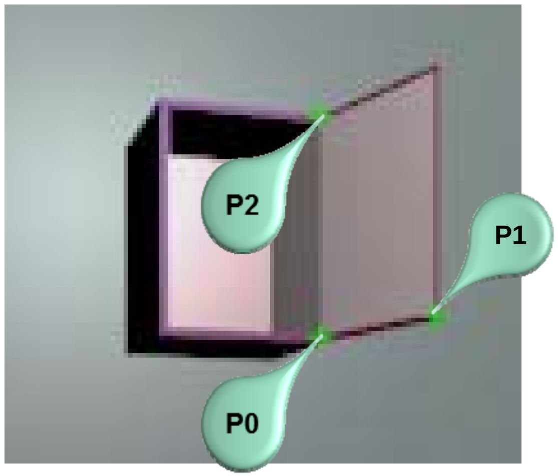
Obstacles detection

Goal: use stereo cameras to detect and classify obstacles from user's requirements list.

Model used:

- triplets of points in 3D, simplest entity both generic and discriminatory;
- first case study: detect planar objects, ie. kitchen cabinet doors. Principle: dense stereo pair $\rightarrow$ sparse 2D corners $\rightarrow$ 3D triplets $\rightarrow$ doors.

From three corners P_1, P_2, P_3 to triplet $\{P_1, P_2, P_3\}$

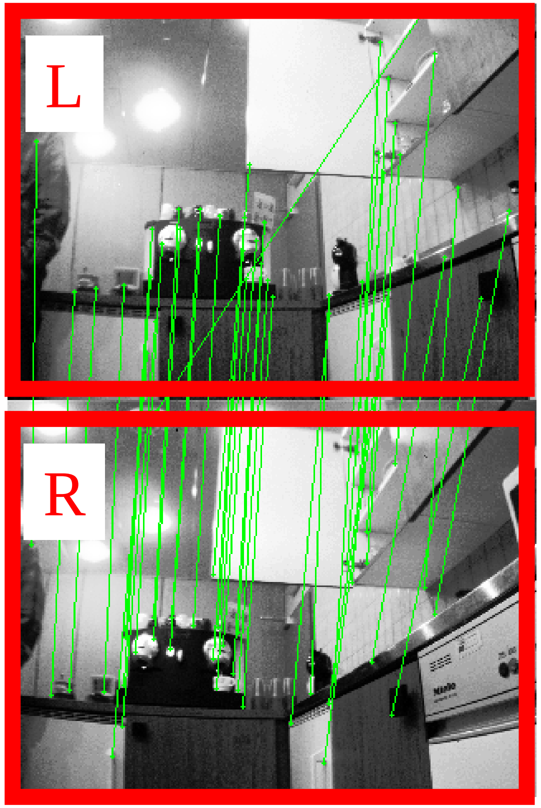


Obstacles detection

Steps:

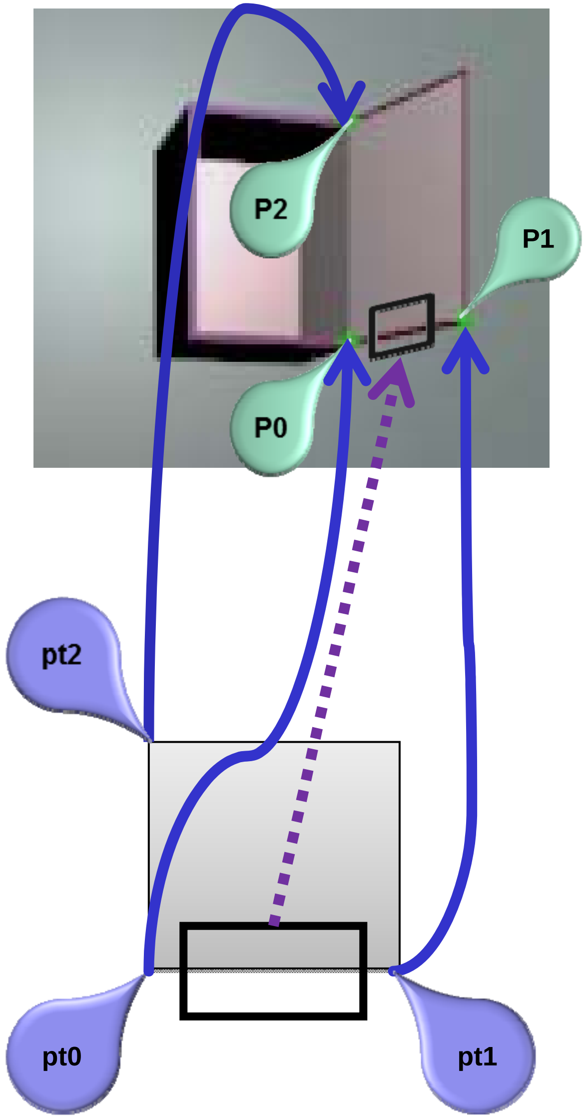
- dense stereo images;
- 2D corner detections on L and R images;
- stereo matching → sparse 3D corners;
- determination of which sets of 3 corners are a valid triplet corresp. to a door: with AdaBoost classifier.

Sample of the training database

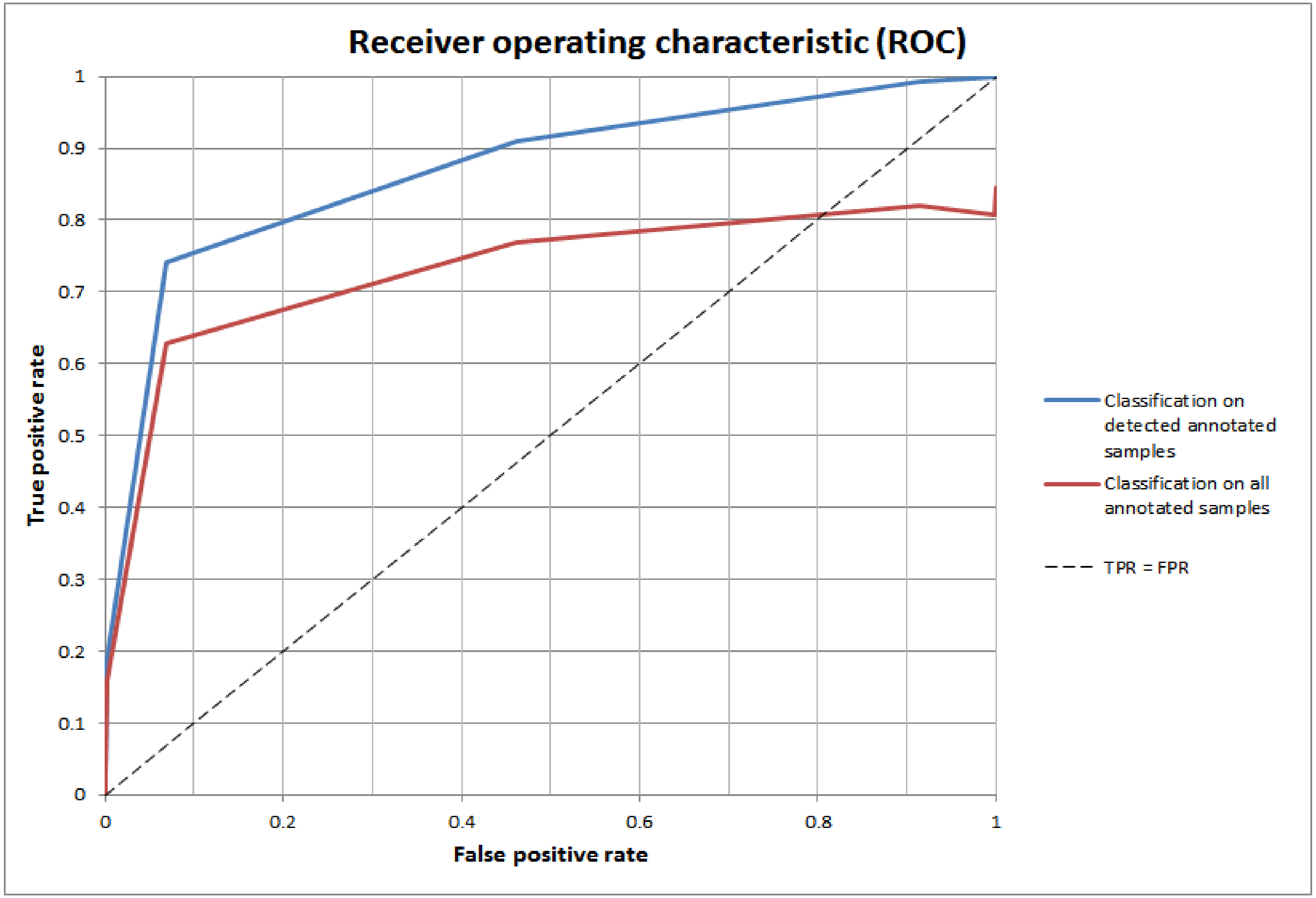


Stereo matching

Obstacles detection



Obstacles detection



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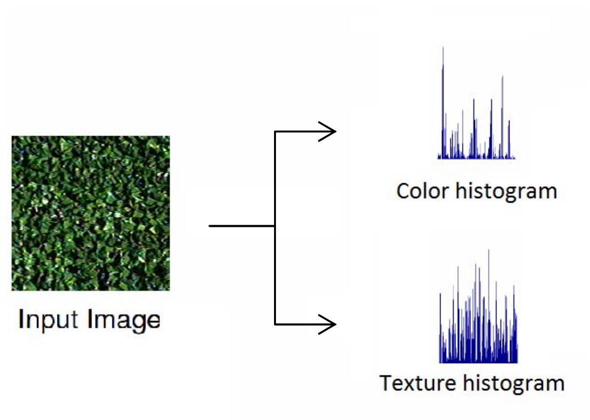
Ground changes detection

Goals:

- detect ground changes and anticipate entering dangerous terrains or situations;
- indoors and outdoors operation.



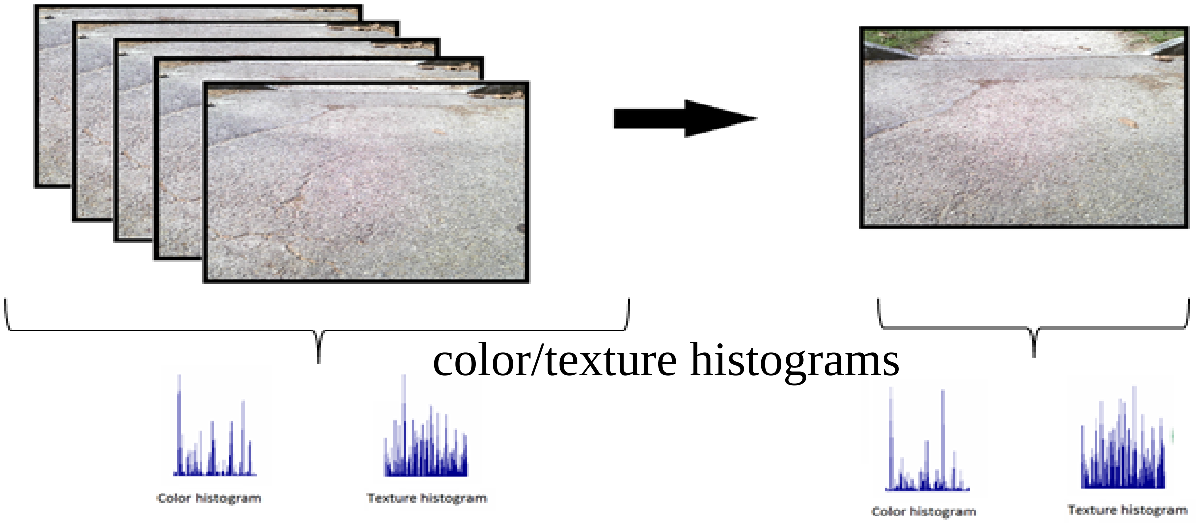
Change in image descriptors:

- 3 colour histograms: HSV model;
- texture histogram:
  Local Edge Patterns (LEP);
- 4 methods to detect changes.

ground truth:

Ground changes detection

Change detection:



Ground changes detection

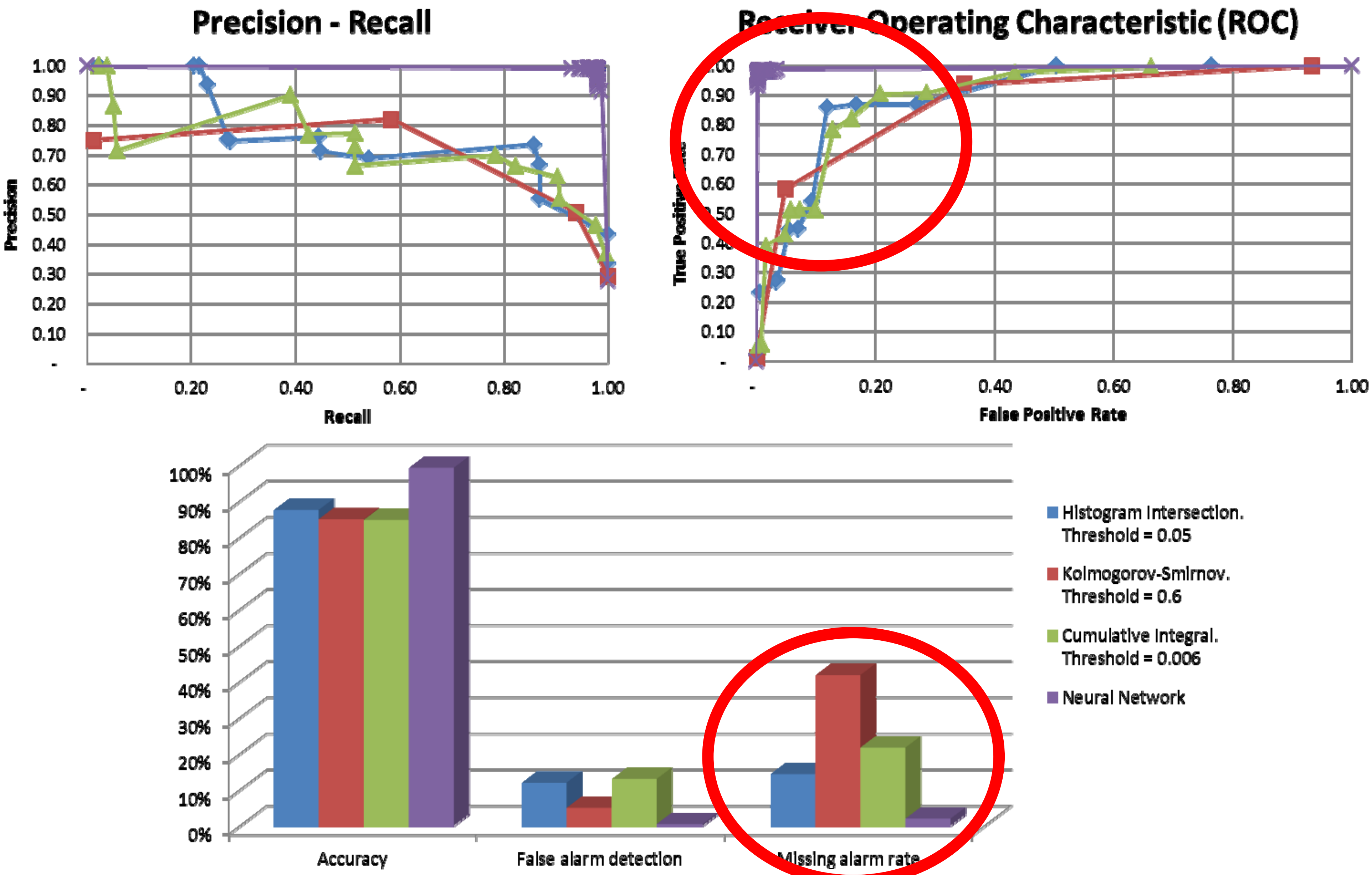
Experimental results:

- camera: Logitech HD Webcam C510 (8 Mpixels), 25 fps;
- 4 training videos, 188 to 313 frames, 6s to 11s, 2 to 4 changes;
- rollator speed 0.65 m/s ~ 2.3 km/h;
- processing time btw input and classif.: 0.1s (HI, KS, CI) to 0.2s (NN);
- latency: 1 frame (NN), ~10 frames (HI, CI), ~30 frames (KS).

Terminology:

		Condition	
		Ground change	**No change**
System result	**Ground change**	True positive (Correct alarm)	False Positive (Unexpected alarm)
	No change	**False negative (Missing alarm)**	True negative (Correct absence of alarm)

Ground changes detection



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Conclusions of experiments

Obstacles detection:

- approach: corner detection and L-R matching, triplet filtering and classification;
- AdaBoost classifier: reasonable predictive accuracy;
- to be improved: pose estimator.

Ground changes detection:

- approach: comparison btw current and past frames;
- best result: fusion of modalities with neural networks;
- good performance in real situations;
- processing time: ~ 0.2 s;
- towards real-time by reducing the size of the neural network.

Conclusions and future work

Actual starting date of the project: May 1st, 2012.

Workplan followed:

- users' requirements;
- setting up hardware;
- objects detection: recognition rate to be improved;
- ground change detection: offline experiments give good results.

Future work:

- obstacle detection: generalize to other objects, port on the Gumstix® embedded platform;
- ground change detection: more real situations (inside, outside). Evaluate Gumstix-Caspa instead of Logitec webcam;
- environment mapping, assessment of user behavior.

Conclusions and future work

Links with 2 Hasler Foundation projects:

- Smartwalker Roboscoop (Bertrand Meyer, Martin Biallas);
- Smart-DAYS (Andres Perez-Uribe).

For instance:

- exchange of technology:
  - Smart-DAYS: activity recognition;
  - Smartwalker: robotics, sensing, mechanized wheeler;
  - Eyewalker: vision, affect estimation;
- use cases;
- benchmarking, usability comparison;
- contacts with public bodies and companies.