

# Biologically Inspired Path Execution Using SURF Flow in Robot Navigation

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# Overview

- **General** path execution control
- Straight forward
- Only using: Camera images
- Without: Artificial landmarks, egomotion
  
- Consecutive frames → Motion information
- Successfully tested on Sony Aibo

# Motivation



# Motivation

- Robot navigation
    - Path planning
    - Path execution
- ↓
- Unexpected behaviour**
- Path execution control is needed !

# Biological inspiration

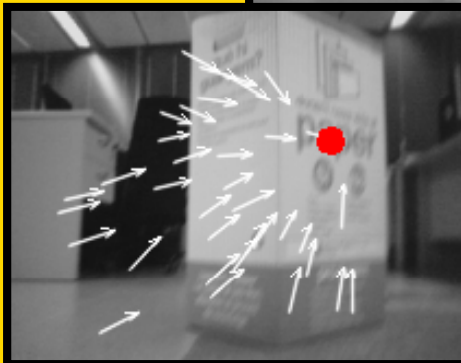
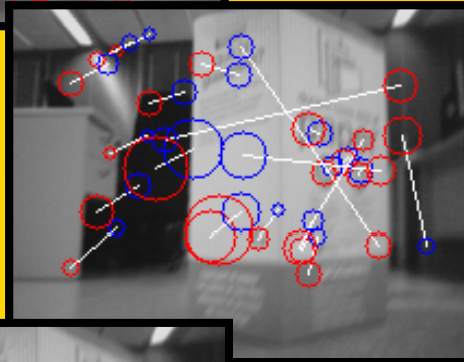
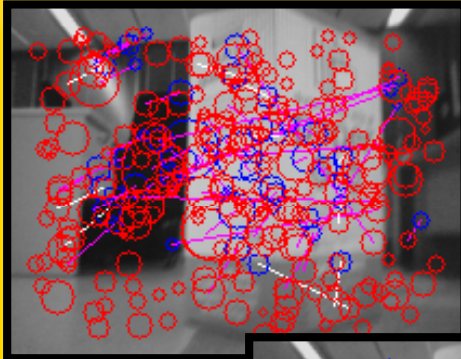
## Biology

- **Insects:** Qualitative 3-D information using image motion to avoid obstacles
- **Humans:** Perception of translational direction of self-motion from optical flow patterns

## Mobile Robotics

- Balance the optical flow divergences between eyes/sides of the image
- This work!

# Navigation Control (I)



1. Motion information from consecutive frames (*SURF flow*)
2. Instantaneous direction of translation (*VP*)
3. Maintain constant the direction (*control goal*)

# Navigation Control (II)

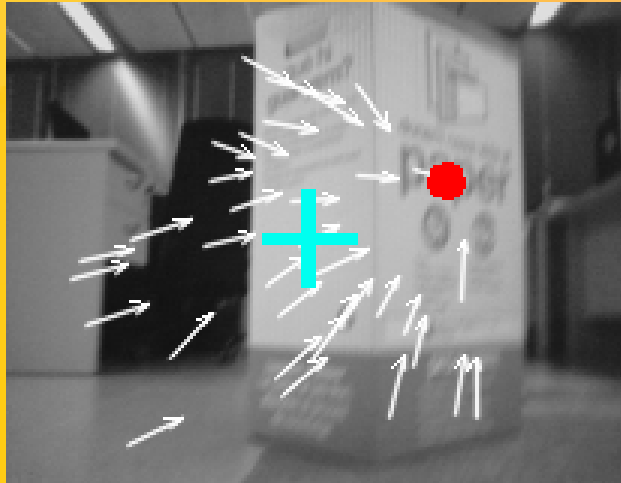
- a) Feedback control
- b) Vanishing Point
- c) SURF flow

# Feedback Control

- a) Feedback control
- b) Vanishing Point
- c) SURF flow



# Feedback Control



- Straight forward displacement
- Goal: Maintain the same orientation
- Error: Image centre - Robot direction

# Vanishing Point

- a) Feedback control
- b) Vanishing Point
- c) SURF flow

# Vanishing Point (I)

## **Motion field:**

*Projection of 3-D relative velocity vectors of the scene points onto the 2-D image plane*

## **Frontal displacement:**

*Vectors radiate from a common origin: Vanishing Point (VP) – Focus Of Expansion (FOE)*

# Vanishing Point (II)

## **Optical flow:**

*2-D displacements of brightness patterns in the image*

**Optical flow = Motion field ?**

# Vanishing Point (IV)

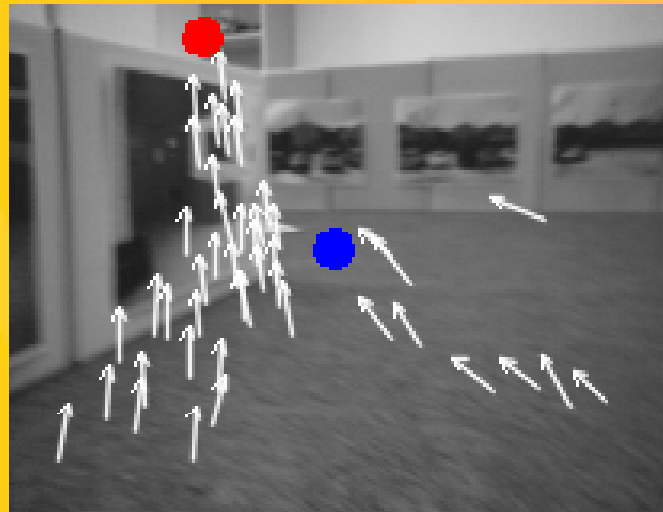
## Restrictions:

- a) Robot moves on a flat ground
- b) Camera translation parallel to the ground
- c) Angular velocity perpendicular to the ground plane

**Robot:** Sony Aibo

# Vanishing Point (V)

- Aibo gait: shocks and vibrations
- Assumption: Restrictions satisfied in average



# Vanishing Point (VI)



# SURF Flow

- a) Feedback control
- b) Vanishing Point
- c) SURF flow

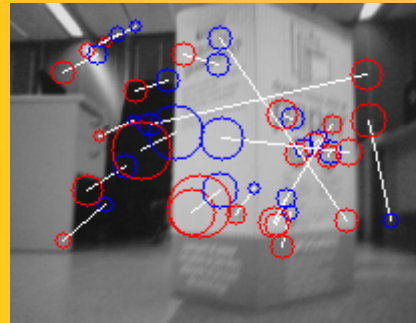


# SURF Flow(I)

## **Optical flow restrictions:**

- Brightness constancy
- Temporal persistence
- Spatial coherence

# SURF Flow(II)



1. Corner detection
2. SURF description & selection
3. Correspondences
4. Vector intersections
5. Vanishing Point

# Experiments

- Robot: Sony Aibo ERS-7
- PC - robot processing (*wireless*)
- Sampling time: 100ms
- Path execution
  - Collision avoidance
  - Straight forward control

# Results (I)



# Results (II)



# Conclusions

- Only camera images are used
- Biologically inspired navigation
- Without artificial landmarks or egomotion
- **Exportable system**
- **Problems with wireless connection**

# Future work

- Wheeled robots
- Correct robot trajectory using motor information
- Take in account robot information
- Sampling rate decreasing



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# Thanks for your attention

Questions?

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