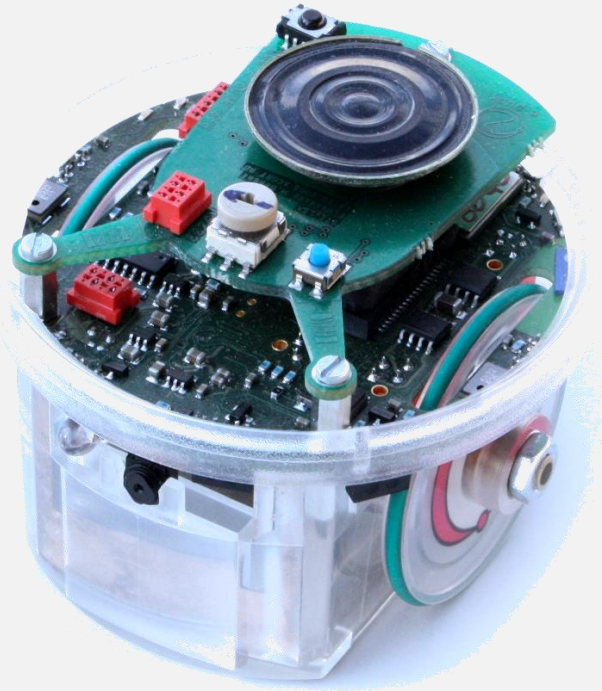
LINE FOLLOWING USING AN E-PUCK'S CAMERA

Signals, Instruments and Systems

Course Project



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PROBLEMATIC

Implement various functions on Webots simulator and on real e-puck

- Line finding
- Line following
- Obstacle avoidance
- U-turn

PLAN

1. METHODOLOGY
2. EXPERIMENTS & RESULTS
3. IMPROVEMENTS
4. CONCLUSION

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PLAN

1. METHODOLOGY

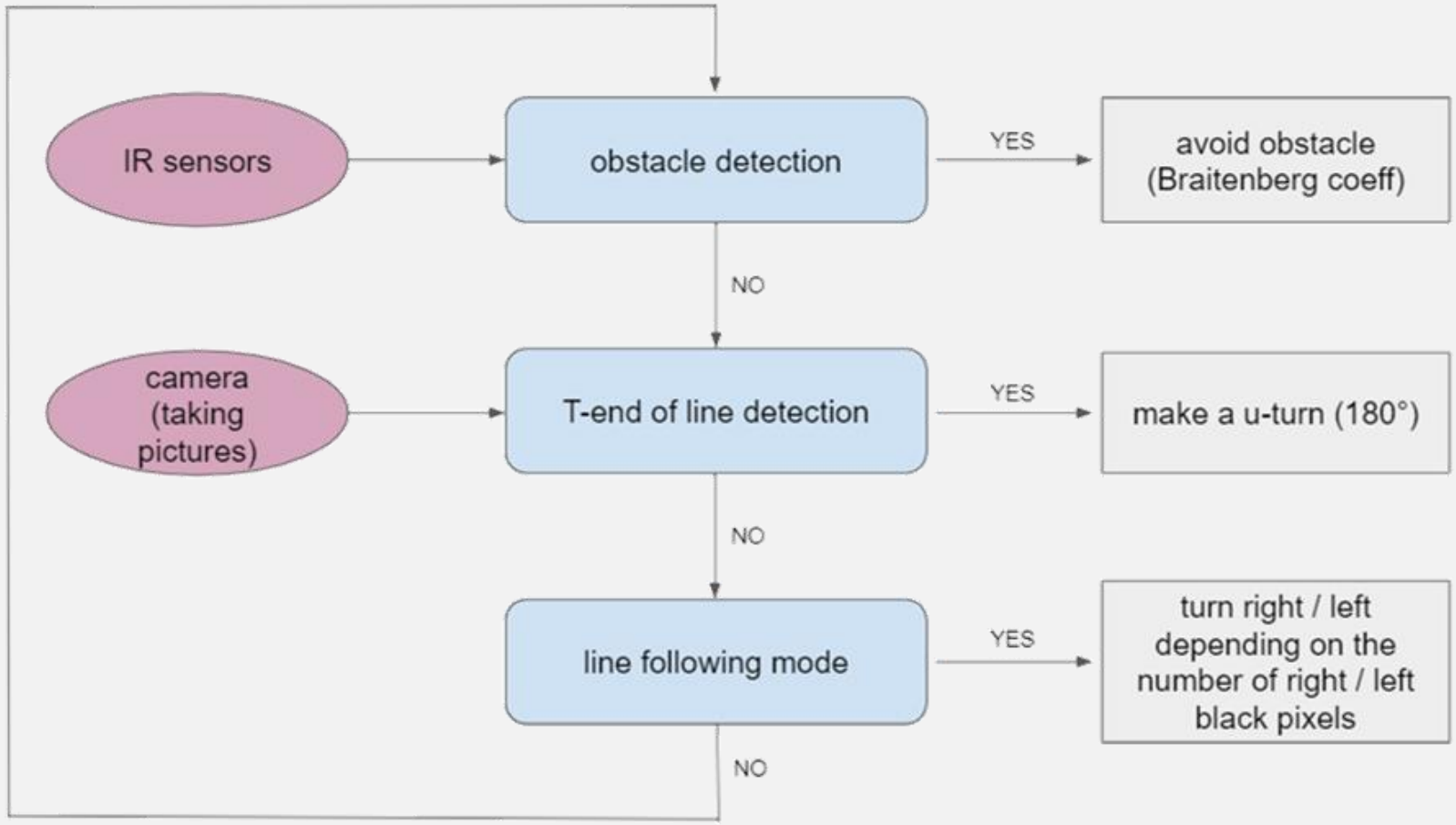
- SENSORS USED
- IMPLEMENTATION STRATEGY

SENSORS USED

- **CAMERA :**
  - Simulation : 52x39 RGB
  - Real : 640x480 panchromatic

- **IR SENSORS** :
  - 8 sensors around the e-puck

IMPLEMENTATION STRATEGY



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2. EXPERIMENTS & RESULTS

- LINE FOLLOWING
- OBSTACLE AVOIDANCE
- END OF LINE
- LINE FINDING

LINE FOLLOWING

- **IMPLEMENTATION**
  - Set a threshold for pixel color
  - Compare left and right pixels’ number
  - Set wheel speed in consequencies

LINE FOLLOWING

- IMAGE PROCESSING
  - Simulation :
    - Gray level
    - Threshold = 20
    - Treat 5 bottom lines
  - **Reality**
    - Camera setting : 16x160, subsampling 4x4, grey scale
    - Threshold : mean pixel color value
    - Treat 3 bottom lines

LINE FOLLOWING

- **SETTINGS :**
  - Margin of error : 5 pixels

Simulation		Reality	
MaxSpeed = 1000		DefSpeed = 70	
Difference	Not difference	Differrence	Not Difference
0,5 & 0,3	0.8 & 0.8	1 & 0.6	1 & 1

LINE FOLLOWING

- **RESULTS**
  - **Test on different shapes :**

Oval line Funky line Square

  - **Test with different width**
  - **Test with different colors**
  - **Test on shadow and brightness**

E-puck – following depending on line width		
Line	Curved	Right angle
Inferior buffer	7 – 9 mm	17 – 20 mm
Optimal width	**7 – 35 mm**	**25 – 40 mm**
Superior buffer	35 – 40 mm	40 – 50 mm

E-puck – line following success rate				
Line	Oval	Funky black	Funky blue	Square
Line width	33mm	35mm	11mm	12mm
Success rate	100%	90%	Not fully success	0%

OBSTACLE AVOIDANCE

- **IMPLEMENTATION**
  - **Concept of Braitenberg vehicle**
  - **Adapt coefficient**

Braitenberg coefficient – Webots								
Sensor	IR0	IR1	IR2	IR3	IR4	IR5	IR6	IR7
Left	-1.5	-1.0	-0.5	0	0	0	0.5	1.0
Right	2.0	1.25	0.5	0	0	0	-0.5	-0.5

Braitenberg coefficient – E-puck								
Sensor	IR0	IR1	IR2	IR3	IR4	IR5	IR6	IR7
Left	175	250	-25	-100	50	20	-150	-75
Right	-75	-125	20	50	-100	-25	250	125

OBSTACLE AVOIDANCE

- **RESULTS**
  - **Simulation :**
    - **Good avoidance**
    - **Not turning around the obstacle**
  - **Real :**
    - **Well turn around**
    - **Not going back to the line**

END OF LINE

- **IMPLEMENTATION**
  - **Compare first and fourth line**
  - **Check right and left ends pixels of first line are not colored**
  - **Opposite wheel speed and adapted wait**

  - **On real world : adaptation to line width**

END OF LINE

- **RESULTS**
  - **Simulation: Good success on the line tested**
  - **Reality : effective if T-ending placed after a straight line.**

FIND THE LINE

- **Not implemented**
- **Random trajectory is enough to find the line**
  - **Simulator : wall and obstacle avoidance**
  - **Real : curved trajectory**

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IMPROVEMENTS

- **Optimisation of main functions :**
  - **Avoid obstacles**
  - **T-ending line**
  - **Line following**
- **Optimisation of parameters and coefficients :**
  - **For a world with shades**
  - **Small line width**
- **Optimisation of image treatment (Fourier transform and filter (FFT))**

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CONCLUSION

- This project was a great experience !
- It taught us to be perseverant and patient
- It developed our experimental approach
- It improved our programming skills

END

Thanks for your attention !

Any questions ?