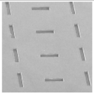

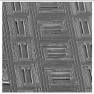

smartsurface

ANR

A Framework to Calibrate a MEMS Sensor Network

Kahina Boutoustous, Eugen Dedu and Julien Bourgeois

University of Franche-Comté, France

UIC, Brisbane, Australia
08/07/09

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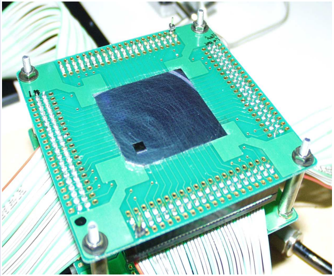
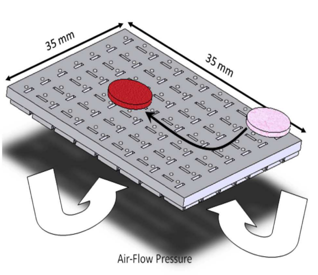
Plan

Smart Surface project

Objectives

An autonomic surface, composed of a large number of micro-actuators which work together to sort and position micro-objects





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Smart Surface project

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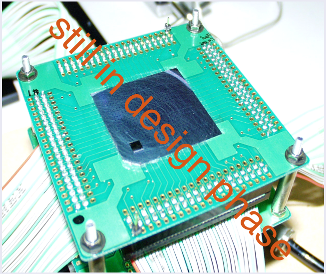
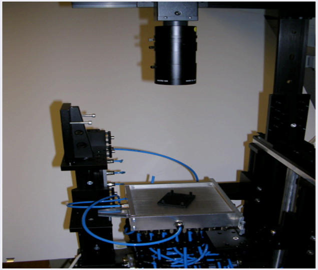
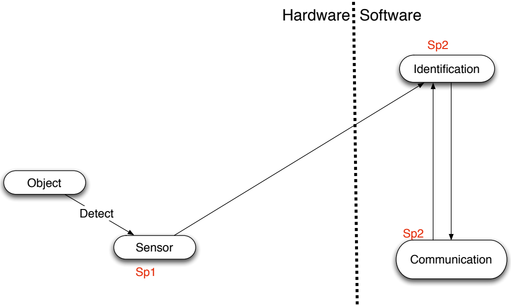




Smart Surface project

Problematic

- Collaboration of several laboratories in various disciplines
- Open problems in each scientific field



Smart Surface project

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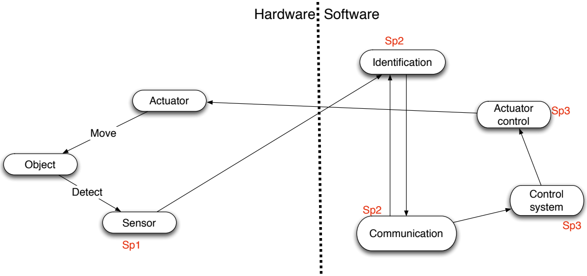

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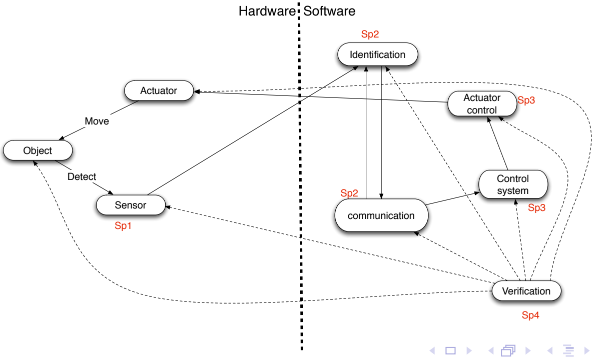

Related work
Micro-manipulator

Micro-manipulator without contact
- Electromagnetic, pneumatic

Advantages
- More robust
- Can't damage the part and/or the surface

Drawbacks
- High cost
- More complicate to design
- Difficult to control, precision problem

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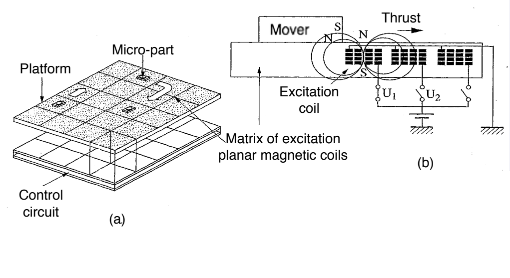
Related work

Example of a micro-manipulator with out contact

Electromagnetic

H. Nakazawa, Y. Watanabe, O. Morita, M. Edo, and E. Yonezawa. The two-dimensional micro conveyer : principles and fabrication process of the actuator. Solid State Sensors and Actuators, 1997. TRANSDUCERS '97 Chicago., 1997 International Conference on, 1 :33{36, Jun 1997.}



Related work
Micro-manipulator

Micro-manipulator with contact

- Ciliary actuator arrays, electrostatics, roller wheels

Advantages

- Easier to design
- Can move heavier objects

Drawbacks

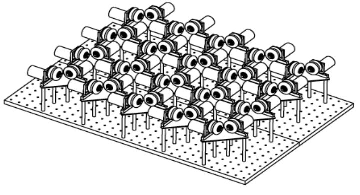
- Lower speed
- Less robust
- Can damage the part and/or the surface

Related work

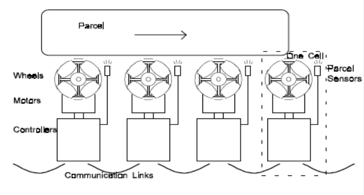
Example of a micro-manipulator with contact

Roller

Jonathan E. Luntz,William Messner, and Howie Choset. Parcel manipulation and dynamics with a distributed actuator array : The virtual vehicle. In IEEE Int. Conf. on Robotics and Automation (ICRA), pages 1541{1997.}



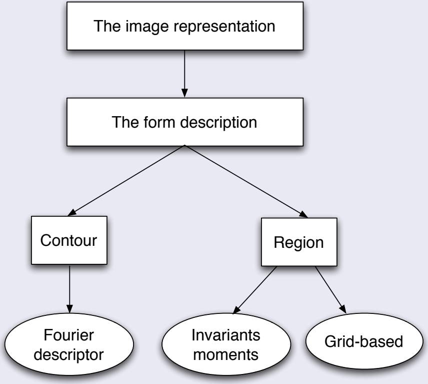
(a)



(b)

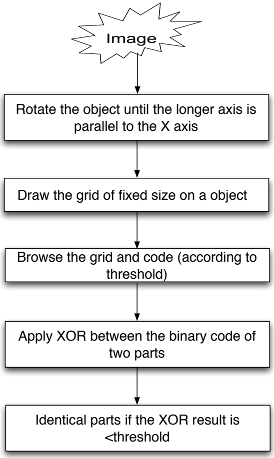
Related work
Differentiation methods

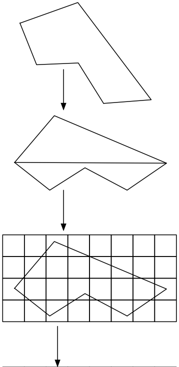
Differentiation methods



Related work

Differentiation methods : Grid based





0	0	1	0	0	0	0	0
0	1	1	1	1	0	0	0
0	1	1	1	1	1	1	0
0	0	1	0	0	1	0	0

SNC

How many sensors are needed to differentiate three parts ?

Objectives

- Determine the number of sensors required for optimal functioning of the Smart Surface
  Optimal functioning = a good differentiation average for each group of models

Hypotheses

- Differentiate parts ($\neq$ recognize)
- All combinations of three out of four models
- The differentiation is done by calculating a set of simple criteria that can be distributed
- Free rotation

The SNC Calibrator
Some definitions : criteria

Definition of criteria

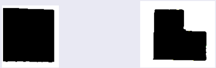
- Example : the criterion «Y»

$$P = \{(x, y)/S(x, y) = 1\}, \ \textit{with S sensor matrix}$$

$$Y = \prod_{c_1 \in P} \prod_{c_2 \in P_{c_1 \neq c_2}} d_M, \ \textit{with } d_M = |c_1(x) - c_2(x)| + |c_1(y) - c_2(y)|$$

$$Y = (1x2x1x2x3x2)x(...)x...$$

Example



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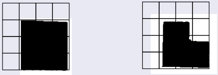

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$$Y = (1x2x1x2x3x2)x(...)x...$$

Example

1	1	1
1	1	1
1	1	1

1	1	0
1	1	1
1	1	1

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The SNC Calibrator

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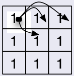

1	1	0
1	1	1
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The SNC Calibrator
Some definitions : criteria

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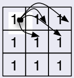

1	1	0
1	1	1
1	1	1

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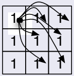

1	1	0
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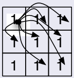

1	1	0
1	1	1
1	1	1

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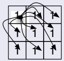
Example



Y=228

1	1	0
1	1	1
1	1	1

Y= 72

The SNC Calibrator

How many sensors are needed to differentiate three parts ?

Some definitions : differentiation ratio for G1= {P1, P2, P3}

1	1	0
1	1	0
0	0	0

P1

1	1	0
1	0	0
1	0	0

P2

1	1	0
1	0	0
0	0	0

P3

	S	P	A
P1	4	8	4
P2	4	10	5
P3	3	8	5

Value of associated criterion for each part

The SNC Calibrator

How many sensors are needed to differentiate three parts ?

Some definitions : differentiation ratio for G1= {P1, P2, P3}

Differentiation matrix of G1 according to the criterion S, area

	P1	P2	P3
P1		0	1
P2			1
P3			

Differentiation matrix of G1 according to the criterion P, perimeter

	P1	P2	P3
P1		1	0
P2			1
P3			

Differentiation matrix of G1 according to the criterion A, number of angles

	P1	P2	P3
P1		1	1
P2			0
P3			

	S	P	A
P1	4	8	4
P2	4	10	5
P3	3	8	5

Value of associated criterion for each part

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P1		0	1
P2			1
P3			

Differentiation matrix of G1 according to the criterion P, perimeter

	P1	P2	P3
P1		1	0
P2			1
P3			

Differentiation matrix of G1 according to the criterion A, number of angles

	P1	P2	P3
P1		1	1
P2			0
P3			

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P2			1
P3			

Differentiation matrix of G1 according to the criterion P, perimeter

	P1	P2	P3
P1		1	0
P2			1
P3			

Differentiation matrix of G1 according to the criterion A, number of angles

	P1	P2	P3
P1		1	1
P2			0
P3			

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	P1	P2	P3
P1		0	1
P2			1
P3			

Differentiation matrix of G1 according to the criterion P, perimeter

	P1	P2	P3
P1		1	0
P2			1
P3			

Differentiation matrix of G1 according to the criterion A, number of angles

	P1	P2	P3
P1		1	1
P2			0
P3			

	S	P	A
P1	4	8	4
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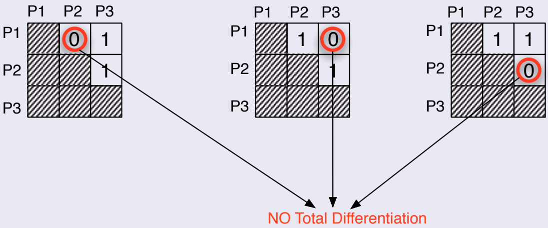
Differentiation matrix of G1 according to the criterion A, number of angles



	S	P	A
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Value of associated criterion for each part

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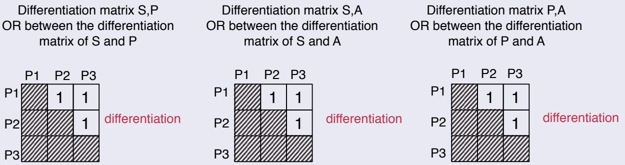
The SNC Calibrator

How many sensors are needed to differentiate three parts ?

Some definitions : differentiation ratio for G1= {P1, P2, P3}



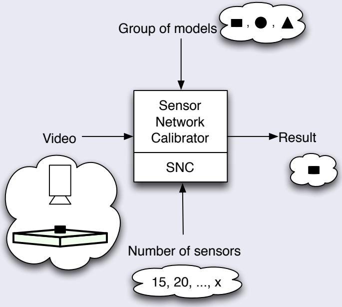
	S	P	A
P1	4	8	4
P2	4	10	5
P3	3	8	5

Value of associated criterion for each part

The SNC Calibrator

How many sensors are needed to differentiate three parts ?

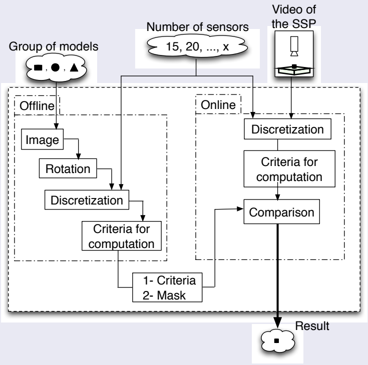
Overview of the calibrator



The SNC Calibrator

How many sensors are needed to differentiate three parts ?

Global structure of our calibrator

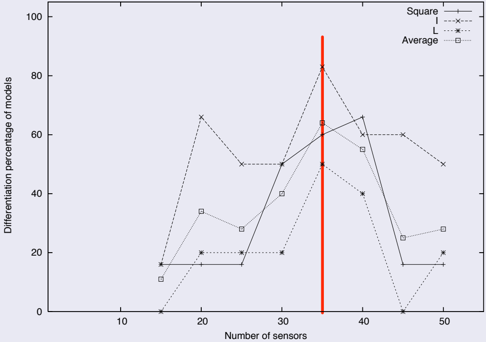


Results

Example of models

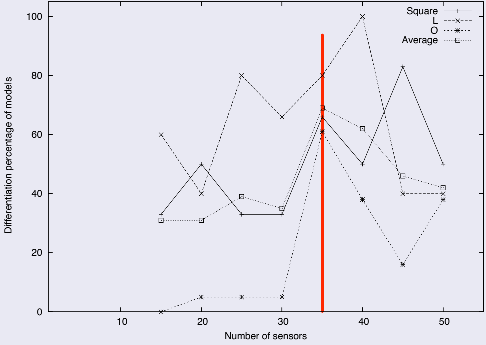
Results

Group square, I, L



Results

Group square, L, O



Results

Computing the non differentiation ratio

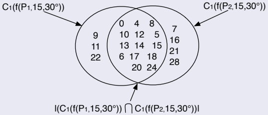
- Let R be a set of rotation values $R = \{1^\circ, 2^\circ, ..., 360^\circ\}$
- N is set of values of grid sensors size N={15, 20,...,60}
- C_k function that calculates the values of criteria
- $f(P_j, n, r))$ function that calculates the binary representation of the model P_j according n step of rotation and r value of grid sensors

$$NDR(C_k, P_i, P_j, n) = \frac{|C_k(f(P_i, n, r))_{\forall r \in R} \cap C_k(f(P_j, n, r))_{\forall r \in R}|}{|C_k(f(P_i, n, r))_{\forall r \in R} \cup C_k(f(P_j, n, r))_{\forall r \in R}|}$$

Results

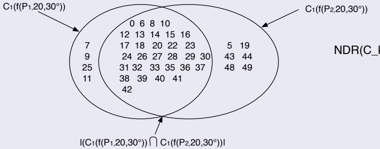
Example

15 sensors



$$NDR(C\_k,P\_i,P\_j,n) = \frac{14}{21}$$

20 sensors



$$NDR(C\_k,P\_i,P\_j,n) = \frac{31}{41}$$

Conclusions and future works

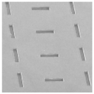
Conclusions

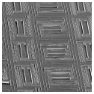
- The SNC calibrator :
- A sensor grid of $(35, 35)$ is an appropriate parameter for the Smart Surface

Future works

- Test our SNC calibrator with other models
- Develop distributed algorithms for various criteria
- Implement our distributed algorithms in the Smart Surface

Thank you for your attention





Questions ?