ECHORD++

The European Coordination Hub for Open Robotics Development

3D Smart Sense and Control

Flexible Robotic Solutions

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Background / motivation

- manual uncoating of cheese blocks (removing thin layer of coating) is very tedious
- robotic automation is very challenging:
  - geometry of cheese blocks varies
  - execution by human is very fast
  - cheese loss has to be minimized

- solutions proposed by others (3D scanning station followed by robotic uncoating station) require unrealistic absolute accuracies
- our solution: 'on-the-fly', i.e. scanning and uncoating in one robot motion
- E++ demonstrator objectives:
  1. not more than 30% slower than human
  2. less cheese loss (4-5% instead of 5-6%)
  3. use advanced constraint-based task-specification language (*eTaSL)*

Starting point / end point

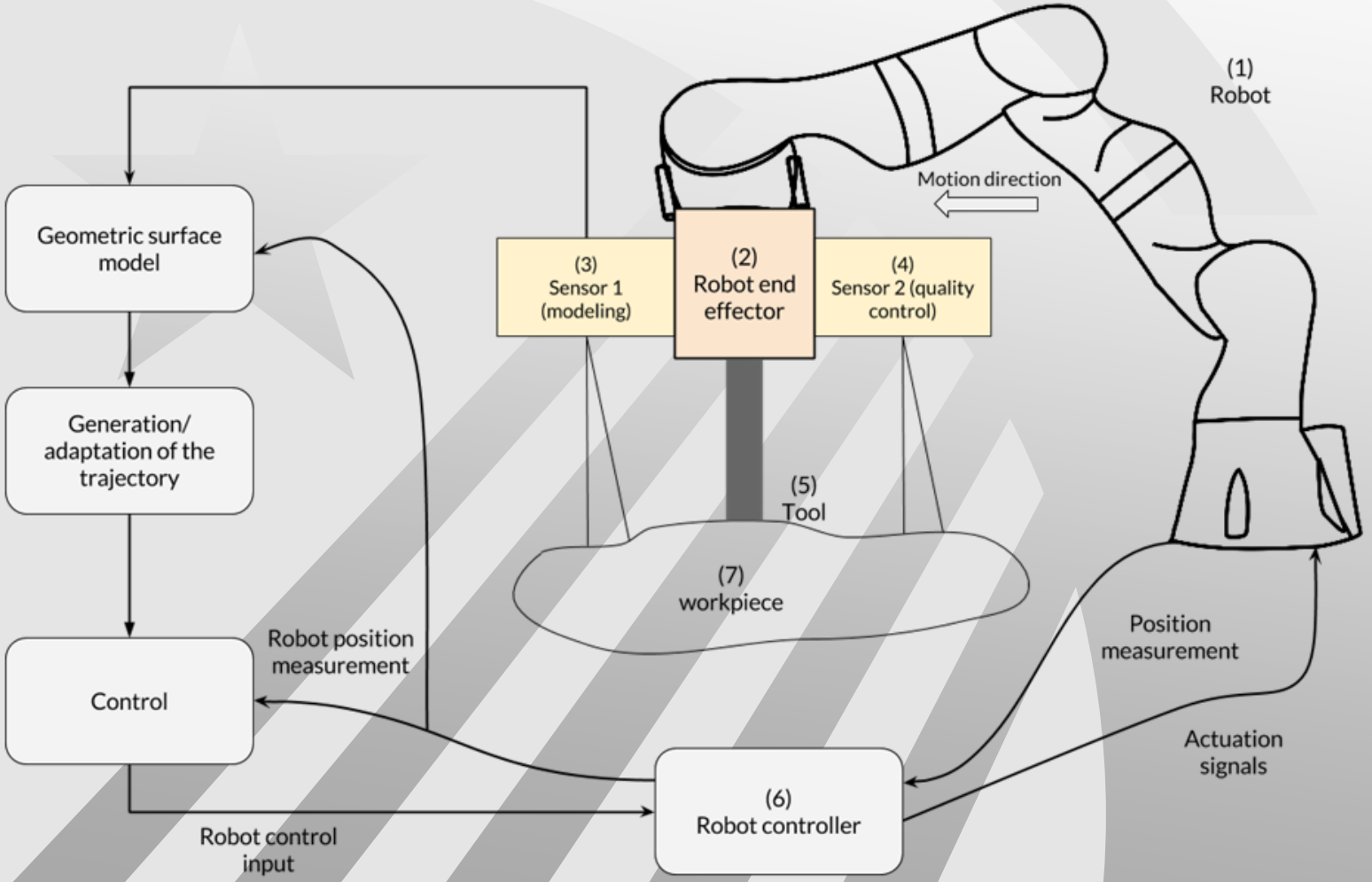
- 3D surface following based on force feedback → slow!
- 3D laser-based sensing for object localization
- *eTaSL* language for constraint-based task specification

- very fast (> 300 mm/s) and accurate (0.1 mm) surface following using on-the-fly surface modelling and feedforward control
- upgrades of *eTaSL* to enable high-performance application
- working prototype

3D Smart Sense and Control			
Confidential information for internal use of E++ core consortium and reporting to the EC*	**Increase in TRL of the product/service during the experiment**		
	At the start: 3	At the end: 5-6	Expected in the next 2 years: 7-8
	Number of patents generated from the experiment		
	At the end: 1	Expected in the next 2 years: 1 or 2	
	Number of jobs created (including PhD students)		
	During the run-time of the experiment: 2	Expected in the next 2 years: between 5-7	
	Turnover from the experiment (in Euros)		
	At the end: 0	Expected in the next 2 years: 700K to 1,5 Mio,-€/yr	
	Applications in number of other areas		
	At the end: 0	Planned in the next 2 years: 1	
	Other areas: Manufacturing – polishing.		

Demonstrator/ prototype

hardware set-up and algorithmic flow chart diagram



Demonstrator/ prototype

video live demo

Commercialization plan

Work to do before Commercialisation

Development – hardware :

- redesign tool (suction, noise, mechanical robustness, hygiene, color sensor, make sure that all sides of cheese block can be processed, laser line scanner if required)
- further speed up cutting process if possible
- peripheral equipment: turntable or conveyor; equipment to turn over cheese block

Development – software – low-level: finetune and optimize surface estimation and control to further increase speed and accuracy

Development – software – high-level

- rough localization of cheese block using global low-cost 3D vision (RGB-D)
- high-level strategy for each type of cheese block (customization): strategy for upper and lower surface, strategy for side surfaces
- quality monitoring using color sensor(*) on-line adaptation of cutting depth, local repass to remove rest coating and stamp

Integration: integrate hardware and software (low-level + high-level), automate sensor+tool calibration procedure, comply with hygienic requirements

Validation: experiments with larger batches of different types of cheese blocks

Commercialization plan

Short term business outlook

FRS has promising business outlook with 2 multinational companies. Both required FRS to sign an NDA in order to give FRS access to their cheese processing plants and their product & process information. Consequently, FRS cannot disclose much in the media.

- Cheese Processing: Friesland Campina – world top 5
- Cheese Retail: Colruyt Group – one of Europe largest food retailers

Medium term extension

Extend business towards the world largest companies:

- Cheese Processing: Nestlé, Danone
- Cheese Retail Mega-Chains: Ahold-Delhaize, Aldi, Auchan, Carrefour, Coop (Switserland), Kroger (US), Sainsburry, Wesfarmers (Australia), ...

Note that outside Europe, there is less cheese consumption (Asia) and there is a higher percentage of consumed cheese which is grown in foil which has no coating (USA).
FRS will seek advice to set-up a business structure for this venture.

Planned disclosure

FRS plans to disclose its technology at Fairs from 2018 onwards (fe. Automatica)
A proof-of-concept demo will be shown on the FRS website

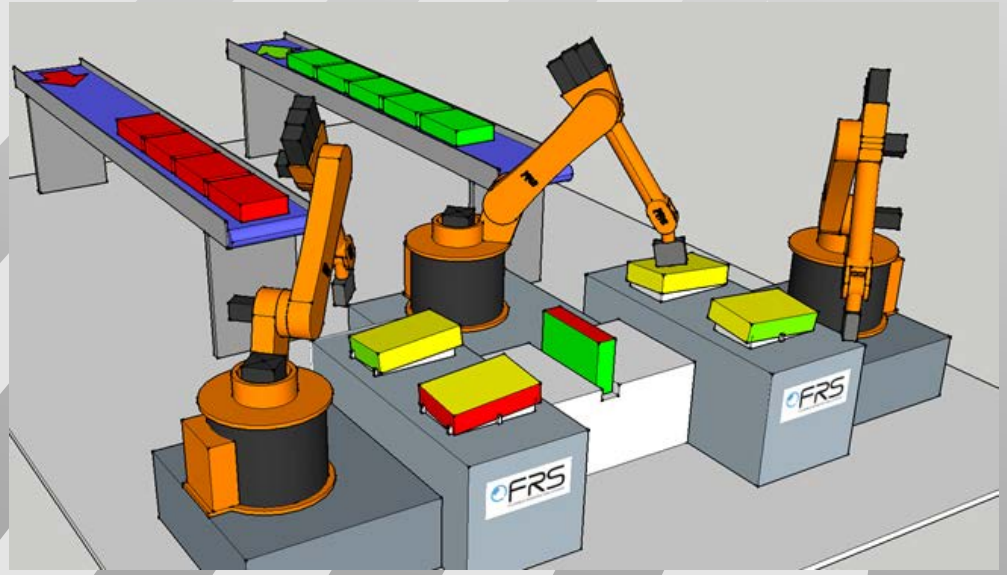
Lessons learned

1. The application turned out to be very complex and challenging (but we were able to master the complexity and overcome the challenges)
2. The obtained accuracy and speed, as obtained using a standard commercial robot, is surprisingly good (but required advanced modelling and control skills); this opens new perspectives for demanding applications involving surface following
3. Increasing the TRL and convincing potential customers is (at least!) as big a challenge as setting up the proof-of-concept demo
4. Participation to the Hannover Messe 2016 required a big time investment and came too early for us (only non-contact surface following was ± ready at this point), hence was good experience but resulted in little benefit
5. Visit to a RIF is not so useful for a company that has all the necessary (industrial) infrastructure and (application-oriented) expertise in-house. It is better to offer this as an opportunity for projects that lack such opportunities (we did not visit a RIF).

Impact from participation in ECHORD++

Impact KPI from Final Report

#	Description	status
1	Direct labour cost saving in comparison to manual work	Achieved
2	Cheese loss reduction	Achieved
3	Selling Price	Achieved
4	Scalability to other manufacturing operations (deburring, grinding, polishing)	Not Achieved



Thank you.

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