Future Opportunities

A European Perspective

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abstract

• Abstract: “Robotics are developing rapidly while the laboratory is often semi-automated at best. The creation of the European working group on analytical laboratory robotics is raising visibility with funders, academia and industry: end users and suppliers. Priorities such as Industry 4.0, the internet of things and autonomous systems are opening the door to new technological possibilities such as the smart connected laboratory as well as new opportunities for collaboration and funding.”

• Biog: Dr Patrick Courtney has 20 years industrial experience in technology development. He worked as Director for global firms such as PerkinElmer, as well as at Sartorius and Cap Gemini, as well as with spinouts, SMEs and clients in sectors such as life science, pharmaceuticals and healthcare. He has a long involvement in EU and national RTD programmes and leads a European working group on analytical laboratory robotics. He is on the board of directors of the non-profit organisation SiLA: standards in laboratory automation
Outline

• Take a step back and see the lab as a whole
  • Robotics and Automation: “analytical robotics”
  • for chemistry, life science, material science
  • Three things we can’t do

• Leverage other technology developments
  • Digitisation and industry “Industry 4.0”
  • German smart lab initiative
  • Research and advances in robotics and AI

• A commercial imperative

• Funding schemes: euRobotics and healthcare robotics
Typology of end-user analytical laboratory

Life sciences
- biomedical research
- pharmaceutical
- clinical
- forensics

Physical sciences
- food & drink
- consumer goods
- materials research
- industrial
- petrochemicals

...missing chemical synthesis
Commercial robots today

The garden, the house, the factory, the street and the operating theatre

Images: wikipedia, Cmglee, iRobot, ABB, Tecan, Rethink, Google
Already 20 & 10 years ago - so why now?

The Automation Partnership: from Cellmate to Compact SelecT

TU München, University of Bielefeld / Bayer (2004)
Already 20 & 10 years ago - so why now?

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EU robotics programme: 2005…2020

New application domains, new robotic forms and novel software capability

Images: CYBERLEGs, CloPeMa, VALERI, AEROARMS, Fraunhofer IFF, iCub/IIT Italy, OCrobotics, Kuka/DLR, Shadow robot
New technological possibilities

interaction and collaboration

logistics and manipulation
What we can and can’t yet do
Towards “analytical robotics”

• Good at liquid handling but still missing:

• Interaction and collaboration: new tasks & new capabilities
  “How to get the most out of my highly skilled scientists?”
  Learning on the job and from examples
  Collaborative robotics: combining strengths

• New robots for existing tasks: logistics and manipulation
  For those hard to automate steps: beyond the microplate

• Getting smarter in the lab:
  “Why can’t I use my smartphone in the lab like I can at home?”
  Other side of the Internet of things: eye/ears – arms/legs
  Cloud chemistry models
What we can and can’t yet do
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Be safe and effective
Avoid material handling, clogging
Log ALL the data
Smartlab at LabVolution Hannover, May 2017
This is what the vision looks like

Smart Glasses And The Lab of The Future
Smart Lab initiative: Industry 4.0

- The digital twin
  - Analytics
  - Visualisation
  - Modelling
  - Simulation
  - Optimisation

- Steps to Lab 4.0

  As resources/services
  + materials/products
  + processes
Smart lab as an information factory

- Workflow from Sample Separation Measurement to Data
- Sample logistics from solid to liquid

from the Information factory to the Idea factory
Please, please!

what the connected lab really looks like today
Towards “analytical robotics”

- **Interaction and collaboration: new tasks & new capabilities**
  “How to get the most out of my highly skilled scientists?”
  Learning on the job and from examples
  Collaborative robotics: combining strengths

- **New robots for existing tasks: logistics and manipulation**
  For those hard to automate steps: beyond the microplate

- **Getting smarter in the lab:**
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  Other side of the Internet of things: eye/ears – arms/legs
  Cloud chemistry models
Learning by example
Performing everyday tasks
The ROBOHOW Vision

realize autonomous robots that can

- read instructions,
- observe the activities of others, and
- generate actionable plans from this information
Entry Point  Pancake Demo

Drew McDermott: “If you know the solution before you have understood the problem you can be sure to be wrong”

insights:
- the amount,
- the breadth, and
- the depth

of the knowledge needed to perform seemingly simple everyday manipulation tasks
Step Change 1: Representation and Reasoning
Step Change 2: Perception
Step Change 3: Semantic Manipulation

Insights: amount, breadth & depth of knowledge needed to perform “simple” tasks
Laboratory automation market
A commercial imperative

A supplier perspective

Opportunity and threat
Typology of end-user laboratory

**Life sciences**
- Pharma R&D $50bn
- Clinical Testing $60bn
- Forensics forensic testing $20bn
- Biomedical research
- Pharmaceutical
- Food & drink $11bn
- Food & drink testing
- Environmental

**Physical sciences**
- Lab instruments $40bn
- Materials research
- Consumer goods
- Petrochemicals

**Industrial**
- Robotics as €2-3bn industry and mostly in Europe
STATE OF THE MARKET NOW

$ 3.92 bil
2016

$ 5.48 bil
2021

This growth is set to be fuelled by:

- Miniaturization
- Lower reagent costs
- Government funding for biotech and drug discovery
- Growth in emerging markets
- Staff shortages
Benefits for new robotic technology

- **Speed:** try out new ideas fast and respond to literature
- **Replication:** repeat and extend previous work
- **Focus:** time to plan experiments and analyse data
- **Collaborate:** sharable robot/lab protocols
- **Better safety** and compliance, less RSI
- **Create sufficient data to demonstrate significance**

Drivers:
- Replication concerns
- Open Innovation
- Time to market
- Safety
- Cost and asset utilisation
- Regulation

Now quantify these...
THE BENEFITS

- Laboratory automation has been shown in peer-reviewed literature to reduce human errors by 50%.
- As such, automation presents an attractive solution for hitting tight deadlines and getting the most out of overstretched teams.

75%

- Implementing laboratory automation systems has shown to reduce the sample turnaround time of a clinical lab by up to 30%.
- A genetic testing lab could see testing times reduced by 50%.
- A drug discovery lab could reduce the process of designing, synthesizing and screening a compound from weeks to days.

REDUCES COSTS

- Reagent savings: One study showed that by automating tissue sample processing they could save 70% on reagents annually.
- Labour: They also found that they could reduce the amount of hands on time by 50%.
- This represents a combined saving of over $250,000 per year.

REDUCES REPETITIVE INJURIES

- 90% of people that pipette in continuous sessions of 1 hour or more report hand pain.
- Studies show that women that pipette 300 hours a year which is only 75 minutes per working day, are at much higher risk of hand and shoulder ailments.

ELIMINATE HUMAN ERROR

- A study from Hofstra University revealed that the average cost of a lost sample was $584 and that sample tracking errors over a 4-month period totalled $20,000 in losses.
- Differences in pipetting between operators has been shown to be up to 11.8% when handling 10 µl. Whilst an automated pipetting system can keep errors below 2%, right down to 1 µl.
Emerald Cloud Lab

“big data + robots = all problems solved”
**MONEY FOR MICROBES**

Investments in synthetic-biology start-ups have increased dramatically in the past three years. Much of the funding comes from prominent technology investors.

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>YEAR FOUNDED</th>
<th>BUSINESS</th>
<th>TOTAL FUNDS (US$)</th>
<th>NOTABLE INVESTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twist Bioscience</td>
<td>2013</td>
<td>DNA synthesis</td>
<td>$82.11 million</td>
<td>Yuri Milner (Internet-company investor)</td>
</tr>
<tr>
<td>Zymergen</td>
<td>2013</td>
<td>Microbial-strain optimization</td>
<td>$44 million</td>
<td>Obvious Ventures; Eric Schmidt (Alphabet executive chairman)</td>
</tr>
<tr>
<td>Ginkgo Bioworks</td>
<td>2008</td>
<td>Microbial engineering</td>
<td>$54.12 million</td>
<td>Matt Ocko (Facebook and Zynga investor)</td>
</tr>
<tr>
<td>Bolt Threads</td>
<td>2009</td>
<td>High-performance fibres</td>
<td>$40 million</td>
<td>Peter Thiel and Max Levchin (PayPal co-founders)</td>
</tr>
<tr>
<td>Transcriptic</td>
<td>2012</td>
<td>Robotics for biology labs</td>
<td>$14.37 million</td>
<td>Jerry Yang (Yahoo co-founder)</td>
</tr>
<tr>
<td>Riffyn</td>
<td>2014</td>
<td>Software</td>
<td>$1.8 million</td>
<td>O'Reilly AlphaTech Ventures</td>
</tr>
<tr>
<td>Emerald Therapeutics</td>
<td>2010</td>
<td>Technology platforms</td>
<td>$34 million</td>
<td>Peter Thiel and Max Levchin</td>
</tr>
</tbody>
</table>
EU opportunities: initiatives, resources & funding

Industrial leadership

Robotics unit
Public Private Partnership
Flagships

Long-term Challenges in
Information and
Communication Sciences
& Technologies ERA-NET

SC1 Societal Challenge 1
aging society

Adalab

autostem

Excellent science
Societal Challenges
EU opportunities: initiatives, resources & funding

Long-term Challenges in Information and Communication Sciences & Technologies ERA-NET

Adalab
AdaLAB Adaptive Automated Scientific Laboratory

• The robot scientist
• knowledge representation
• ontology engineering
• semantic technologies
• machine learning
• bioinformatics
→ automated experimentation

• A biological process from yeast
• Partners: Manchester, Brunel, Paris, Leuven
EU opportunities: initiatives, resources & funding

2018 call robotics smart factory
Publishes June
Opens October

Long-term Challenges in Information and Communication Sciences & Technologies ERA-NET

1. Object recognition and manipulation by robots: Data sharing and experiment reproducibility

The ability of recognising objects and manipulating them is central to robotics. Robots should for example be able to recognise objects mentioned by a user and fetch them or to visually determine if and how an object can be safely grasped. However, despite decades of research, such abilities remain limited in practice. Limiting factors are the lack of large data sets for training robust models for the tasks under study and of objective evaluation protocols to test these models in a reproducible way. A new approach going beyond the organisation of robotics competitions is needed, whereby robotic perceptions about the surrounding environment and internal states are recorded, annotated with reference information usable to evaluate models, and shared across researchers working on the same task.

Application sectors: Industrial and service robotics

Keywords: Robotics, object recognition, image recognition, artificial vision, visual servoing, grasping, object manipulation, perception through interaction, embodied cognition, machine learning, benchmarking, performance evaluation, experiment reproducibility

2. Industrial big data and process modelling for smart factories

Industry and its production plants are increasingly digitized and the production processes generate increasing amounts of heterogeneous data, from simple sensor data to complex 3D video streams. This opens the way for new intelligent, flexible, network-centric production approaches where parts, products and machines are interconnected across plants, companies and value chains. This evolution is often referred to as the fourth industrial revolution. Most industrial sectors are concerned, including aeronautics, energy, chemical industry, dairy farming and 3D industry, among others.

The goal is to enable production at higher yield, higher quality, lower costs, lower environmental footprint and increased flexibility. For that purpose, intelligent context-aware automation systems should be developed. Such systems should be generic enough to be reusable in various settings. One of the research challenges is to combine a priori knowledge about the processes with learning from data.

Application sectors: Industry, manufacturing, maintenance.

Keywords: Smart industry, cognitive plants, advanced manufacturing, predictive maintenance, process modelling, big data, machine learning
EU opportunities: initiatives, resources & funding

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accmet
FP7 Accmet Accelerated Metallurgy

The European Research Roadmap, Metallurgy Europe

• to lay the **technical foundation** for the design and discovery of next-generation alloys, compounds and composites that can be processed into higher-performance metallic components for industrial end-users
• to establish new high-tech **start-ups** and **pilot-scale** factories in Europe
• to develop a **talent pipeline** of well-trained post-docs, PhDs, masters students, apprentices and school children, who will eventually be part of the much-needed metallurgy workforce of Europe
• to create **100,000 jobs** within a decade, comprising both manufacturing and adjacent service jobs
• to develop **1000 patents** in order to secure European independence in metallurgy, as well as the protection of crucial intellectual property for new materials and processes;
• to make a positive contribution to Europe’s GDP and societal wellbeing.

This Roadmap has evolved into a partnership between 260 companies and research organisations throughout Europe which is now established as an EUREKA Network. This program aims to raise up to a 1 billion Euro of funding for metallurgy research throughout Europe over the next 7 years and has been through its first round of applications for setting up projects within the three key areas of: Material discovery, Novel design, metal processing and optimisation, Fundamental understanding of metallurgy

*Metallurgy Europe* is a seven-year EUREKA Cluster Programme (Σ!9169) started in 2014 [15 member states including: Norway, Turkey, CH]
EU opportunities: initiatives, resources & funding

Public Private Partnerships

Flagships
Horizon2020: from PPP to Flagship

• Public Private Partnership: for robotics as “euRobotics”

• Other relevant PPPs:
  • EFFRA European Factories of the Future Research association
  • SPIRE: Sustainable Process Industries through Resource & Energy Efficiency
  • Others (Green vehicles, photonics, green buildings, HPC, 5G…)

• Emerging PPPs: Big Data, Personalised Medicine
  • A filtering process will be applied!
Horizon2020: convergence in euRobotics

- Produce a Multi-annual roadmap
  - Feeds into the work-programme

- Topic groups: technology and market sector
  - Medical
  - Analytical Laboratory Robots
  - Miniaturised Robots

- The Healthcare Lighthouse
The Healthcare Lighthouse vision

Laboratory

Surgery

Care

Rehabilitation
Delegation: Cascade funding projects

Low burden
Part of a focussed call within a large project
Typically €300k 18 month
1-2 partner single country
Horizon2020: from PPP to Flagship

• Flagships €1bn over 10 years
  • 2013: Human Brain, Graphene
  • 2016: Quantum technologies

• Another round is in preparation to compete
EU opportunities: initiatives, resources & funding

Industrial leadership

Robustics unit
Public Private Partnership
Flagships

Long-term Challenges in
Information and
Communication Sciences
& Technologies ERA-NET

SC1 Societal Challenge 1
aging society

Horizon 2020

innovative medicines initiative

FP9

accmet

Adalab

autostem

Excellent science

Societal Challenges
Summary

• Dial-a-Molecule touches on some existing initiatives
  • Laboratory robotics TG, Smartlab, Industry 4.0

• There are commercial imperatives

• There are opportunities to engage with EC
  • PPP: new or existing, cascade funding
  • Societal challenges, flagship…FP9
  • with and without Brexit

• Thank you for listening
Thanks to input from 100+ organisations

- Associations: ELRIG, SiLA, Allotrope foundation; MMIP, EVA, Biolago, Toolpoint, euRobotics Topic Groups in Healthcare Robotics and Miniaturised Robotics

- End users: GSK, AstraZeneca, Boehringer, Curie Inst, QUT, Actelion, Novartis, Synthace, Sellafield, Unilever, Johnson Matthey, Milan University Hospital, Lonza, UCB, MIB, EMBL, Inst. Pasteur, NHM, Biontech; Aachen, QE Hospital Gateshead, Bayer, Grünerenthal, Roche


- RTOs: Fraunhofer IFF/IPA IPT, CSEM, VTT, IIT, Catapult (CGT, MedDisc, HVM)

- Academics groups: University of Manchester, University of Bielefeld, Brunel, Birmingham, Bristol, Bremen, TCI Hannover, Dresden, Rostock, Liverpool, TU Munchen, FH Buchs, HSR Rapperswil, Imperial, Kings college, Copenhagen, Strathclyde, Aachen, TUT, TUWien, ETH-BSSL, ETH-FGZ, Uni Konstanz, NTA-Isny