Transition of Robot Technologies from Academia to Industry

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Introduction

- Technology transfer
  - HP
    - Virus throttling
  - Sana Security
    - Bio inspired intrusion detection
    - Behavior based anti-malware
  - Heartland Robotics
    - Series elastic actuators
Transitioning (robot) research

• Academia -> industry
  – Its hard
  – Not as much transfer as we might hope

• We would like to
  – Understand why
  – Figure out how to get more transfer

• In this talk
  – Case study of Series Elastic Actuator
  – Model of transfer
  – Main issue is structural
  – Suggestions to improve transfer
Series Elastic Actuator

- SEA invented at MIT in 1993
  - Pratt and Williamson (1995)
- Inexpensive way to get good force control
  - Make robots that are compliant, good at tasks, safer around humans, good in unstructured environments etc.
- Spring in series with gearbox
- Turn force control problem into position control
- Spring filters gearbox nonlinearities, gives smooth output torque
- Gain in compliance, sacrifice bandwidth
1993: SEA Invented
1995: First Prototype
1996: First SEA Robots
1997: Patent issued
2000: First SEA company (Yobotics)
1997: Patent issued
2007: More SEA Companies, iWalk, MekaBot
2008: First commercial arms with SEAs
2010: SEA Robot in space
2013: Patent expires

- Increasing use of SEA robots in academia
  - MIT, CMU, Georgia Tech, etc.

- Increasing use of SEA in products
Model of transfer

Technology

- Works in production
- Right cost

Market

- Market Opportunity
- Timing

Intangible

- People
- Luck

Successful Paper

$ $$

Successful Company

Market Success

Patent
Technical challenges

• Turning prototype into a product
• Often a lot of work, e.g. SEA
  – 1.5 man years to prototype
  – Heartland >> 24 man years
• Security software
  – 3 man years to prototype
  – Team of 25 engineers, 6 testers for 2 years to product
• Why does this take such a lot of work?
Product quality

- Attention to detail
  - Manufacturability
  - Cost targets
  - Performance
  - Reliability/fatigue
    - Failure modes
  - Analysis
Technical challenges - testing

• Robotics
  – Durability testing
    • Long term testing
    • Elevated temperature
  – Units running continuously
    • Millions of cycles
• Security software
  – every build 30k automated tests
  – team of 6 working for 2 weeks on final acceptance testing
• This kind of rigor a high bar for an academic paper!
Technical implications for transfer

• Technical bar for academic publication:
  – New work
  – Math and working prototype implementation

• Technical bar for product:
  – Work, work well enough, work long enough, work cheaply enough…
  – Attention to detail
  – Testing

• Robotics add concerns of
  – Cost, manufacturability

• Academics not incented to solve bring-to-market issues
  – Lot of work, little payoff
  – In fact often would make sense to avoid those issues
  – Not seen as increasing state of the art
Market

• Most risky part
• Very hard to predict
  – Very timing dependent
• In SEA history
  – ISRobotics license
  – Yobotics
• Failed because of lack of market
• But later (2009/2010), market better
Market implications for transfer

• Fundamental disconnect:
  – Academics are about technology
  – Companies are about products
    • Largely agnostic of technology

• Mismatch

• Which ideas should academics work on?
  – Hard to tell if ideas are marketable
  – Or when ideas are marketable
  – Guidance and communication

• Need to work on further out problems
  – Take risk they will be irrelevant
Intangibles: People/luck

- People matter
- SEA taken off, largely because people who used it were entrepreneurial
  - Aaron Edsinger -> Mekabot
  - Jerry Pratt -> Yobotics
  - Hugh Herr -> iWalk
- Luck matters
  - Across all aspects
People/luck implications for transfer

- Not all academics are entrepreneurial
  - Hard to expect them to be so
  - Harder to make that a pre-requisite for choosing a research topic
- Can’t make all academics lucky!
  - But can “make own luck”!
Summary

- **Transfer**
  - Technical
    - Academic papers much lower technical bar
    - Does not make sense for academics to do more
  - Market
    - More random, hard to predict
    - Risky
  - Intangibles
    - What really works dependent on people/luck

- **It's worse than this**
  - They are all connected

- **What can be done?**
  - Funding and funding cycles
  - Industrial collaboration and sponsorship
  - Common platforms
  - Networking
Funding

- Funding for research often from governments
- Can be out of step with real issues, or random
- E.g. focus on military applications in US
  - Less focus on cost/performance tradeoffs
- There is increasing industrial participation in these
  - Good sign
  - But…
Industrial collaboration/sponsorship

- Companies funding research
- Can be effective
  - DLR and Kuka
  - ABB and Rosetta project
  - Bluefin and robot clams
- Normally only available to big companies...
- ... which tend to be more conservative
- Smaller companies, which are more innovative can’t afford this
  - Work generally derivative
Common platforms

• Many of technical risks can be reduced if work is originally done on a compatible platform
• More effective for software than hardware
• Ideas implemented on e.g. ROS are easier to pick up and use by others who use ROS

But
  – Adoption of those platforms by companies can be problematic
    • IP issues
    • Existing code base
People

• Best collaboration is people
  – Placements in academic labs
  – Internships
  – Networking
Conclusion

• Transferring academic work to industry
  – Tough, and often a long winding road
• Groups have different incentives, timelines, risks
• Structural differences means changing the kinds of things academics work on makes little sense
• Increase chances of transfer by
  – Increased communication on both sides
  – Making funding relevant
  – Use of standard platforms
  – What else?
Discussion