CHALMERS
UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF GOTHENBURG

Ways of Applying Artificial Intelligence in Software Engineering

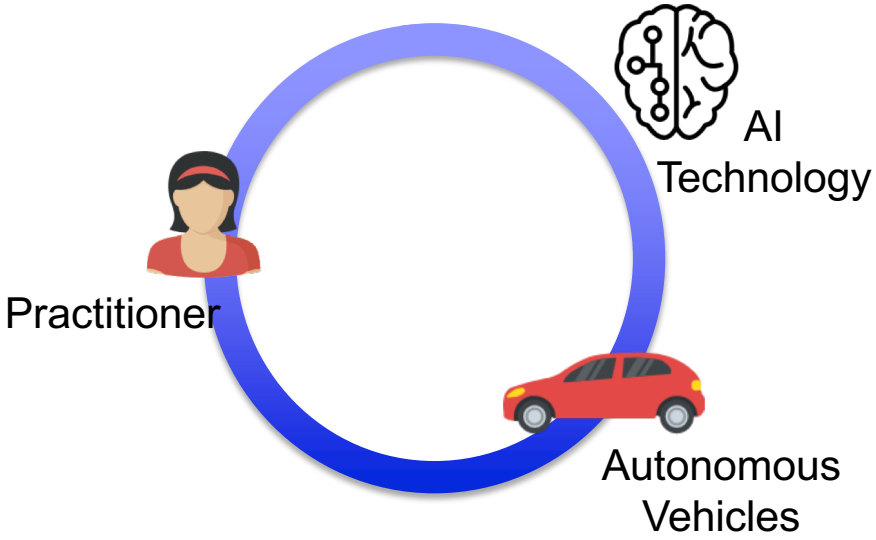
Robert Feldt,
Francisco Gomes de Oliveira Neto,
Richard Torkar

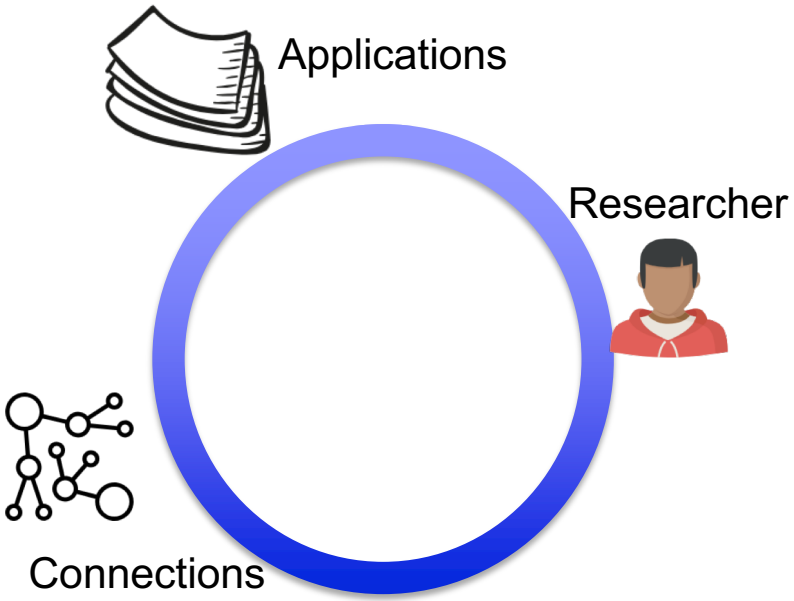
Software Engineering Division
Chalmers | University of Gothenburg
gomesf@chalmers.se
RAISE 2018, Gothenburg, Sweden

Main message

- AI can be applied in many different ways in Software Engineering (SE)
- AI is not a single thing; it's a "moving set" of advanced technologies.
- A simple model of AI-in-SE applications help in analysis and for strategy

Main message





Main message

Artificial Intelligence in Software Engineering Application Levels

AI-SEAL

Taxonomies related to AI

- What's out there?

- Taxonomies related to specific:
  - AI technology
  - Domain specific knowledge

  - All of the above

What's it not about?

the one taxonomy
to RULE them all

Stiff classification

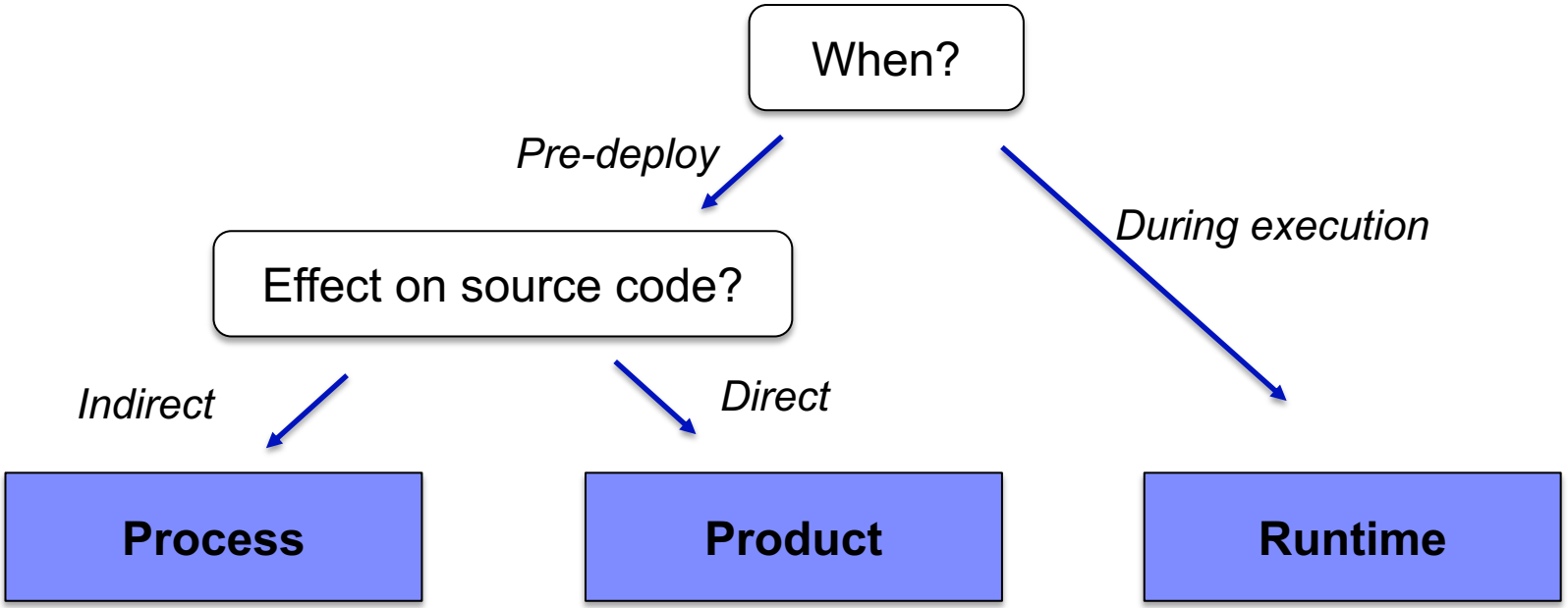
AI-SEAL: Taxonomy

- 3 facets (or levels):
- Point of application - PA
- Type of AI Technology - TAI
- Levels of Automation - LA

Facet 1: Point of AI application

- When are we applying the AI technology?
- On what are we applying it?
- We understand:
  - What's the impact of the AI application?

Facet 1: Point of AI application



Facet 2: Type of AI technology

- **So what is AI then?**

Supporting technologies:

- Advanced statistics
- Clustering
- Optimisation/Search

Tribe	Origins	Master Algorithm
Symbolist	Logic, philosophy	Inverse deduction
Connectionist	Neuroscience	Backpropagation
Evolutionaries	Evolutionary biology	Genetic programming
Bayesian	Statistics	Probabilistic inference
Analogizers	Psychology	Kernel machines

From [Domingos, 2015]: The Master Algorithm

Sheridan (1980) from [Frohm, 2008]

Facet 3: Level of Automation

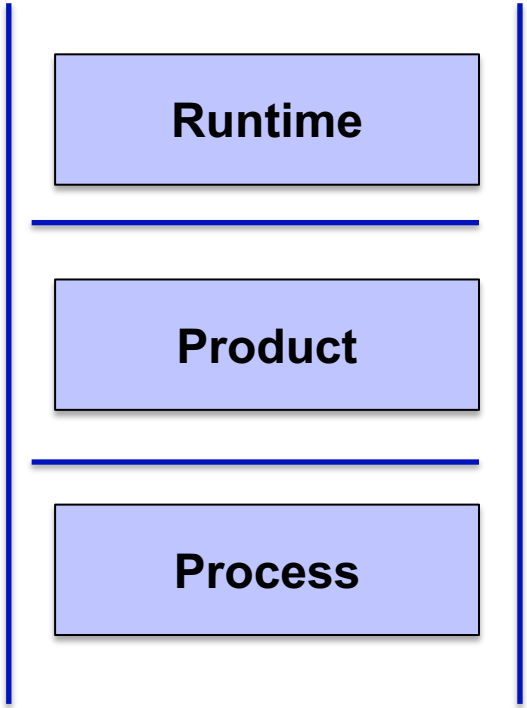
1. Human considers alternatives, makes and implements decision.
2. Computer offers a set of alternatives which human may ignore in making decision.
3. Computer offers a restricted set of alternatives, and human decides which to implement.
4. Computer offers a restricted set of alternatives and suggests one, but human still makes and implements final decision.
5. Computer offers a restricted set of alternatives and suggests one, which it will implement if human approve.
6. Computer makes decision but gives human option to veto prior to implementation.
7. Computer makes and implements decision, but must inform human after the fact.
8. Computer makes and implements decision, and informs human only if asked to.
9. Computer makes and implements decision, and informs human only if it feels this is warranted.
10. Computer makes and implements decision if it feels it should, and informs human only if it feels this is warranted.

AI-SEAL: Levels of Risk

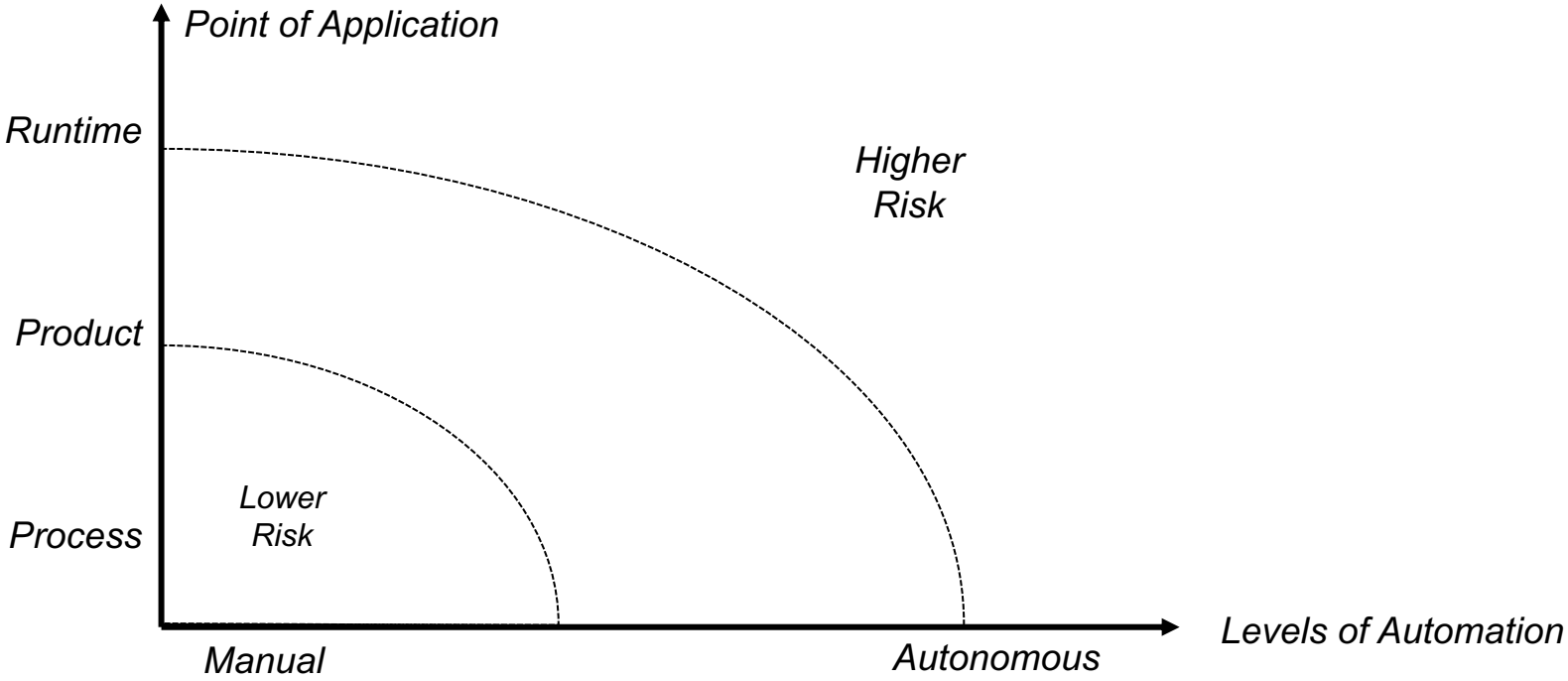
- **A ladder of increasing risk:**
  - Product more risky than Process
  - Runtime more risky than Product

Higher levels of automation == Higher levels of risk

Less time to **reverse decisions**

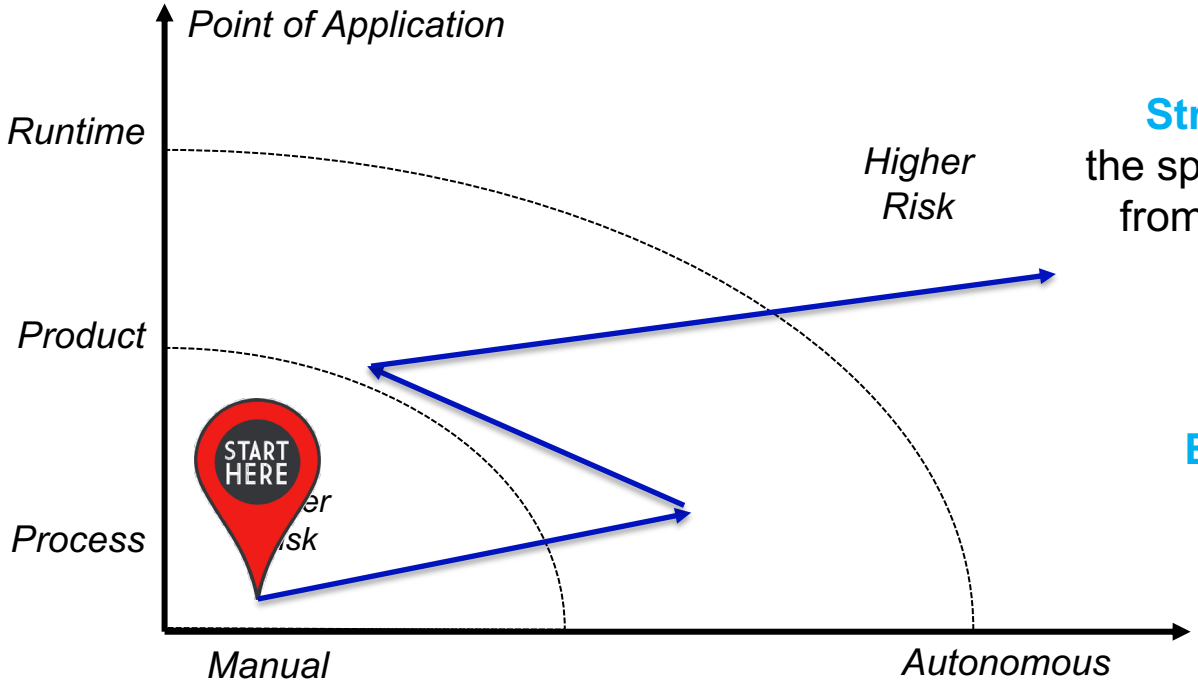


AI-SEAL: Levels of Risk



AI-SEAL: Levels of Risk

If unaware where to begin,
Start at lower risk areas



Strategically move throughout the space, based on lessons learned from applying AI technology in SE

Be aware *where to move and the underlying risks*

AI-SEAL: Levels of Risk

- Thus:
  - If an AI technology is **new to a company**,
    - start at **low level of automation** & at a **“lower” point of application.**
  - Build more experience then **expand “out and up”**

Process + **LA = 1 - 3**

AI-SEAL Taxonomy: Utility demonstration

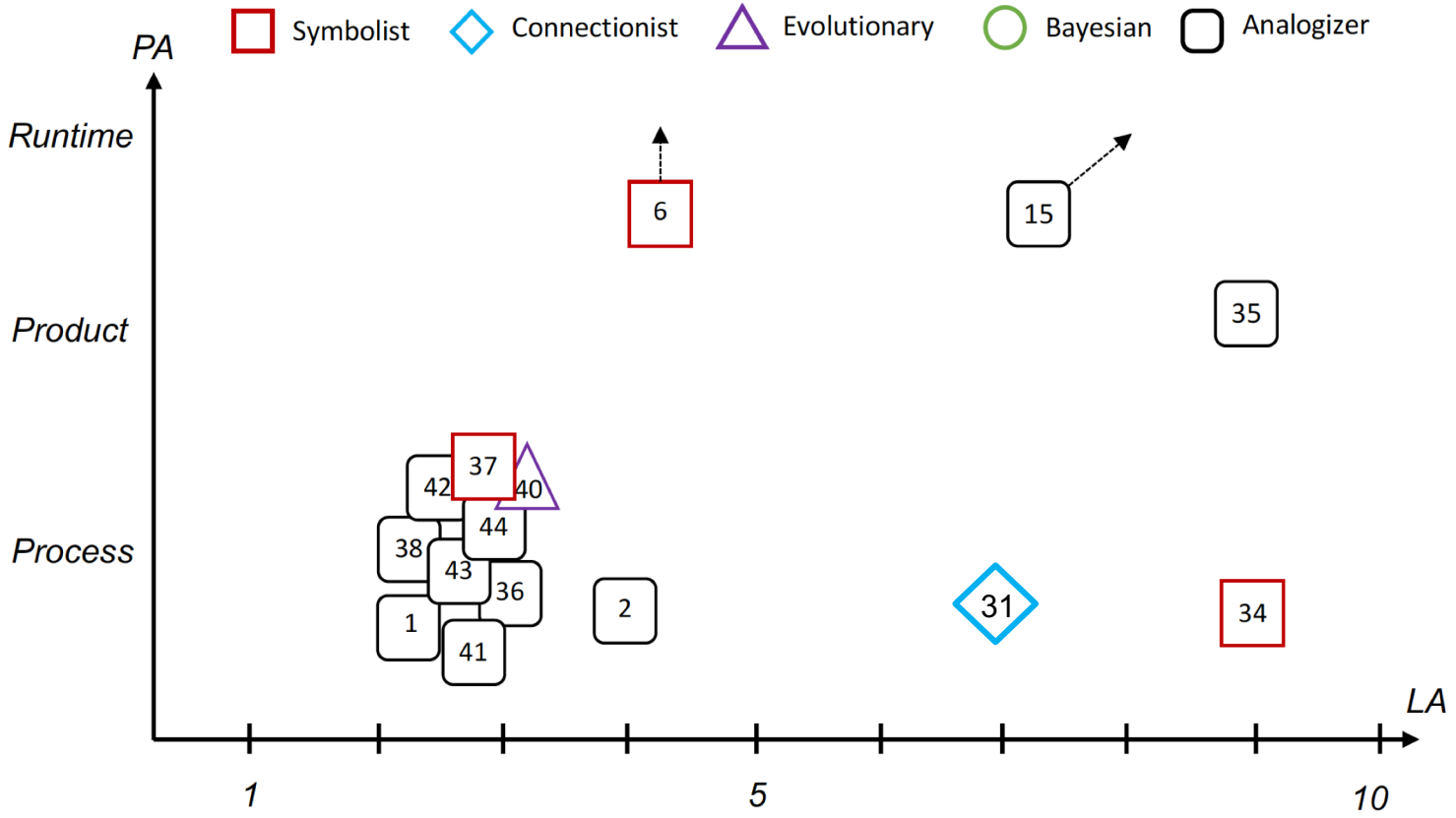
- **Try it out on different papers**
- **RAISE workshop (2012 – 2016)**
- **44 papers: 15 classified**
  - All 2015 + 2016 papers (11 papers)
  - Random from other editions (4 papers)

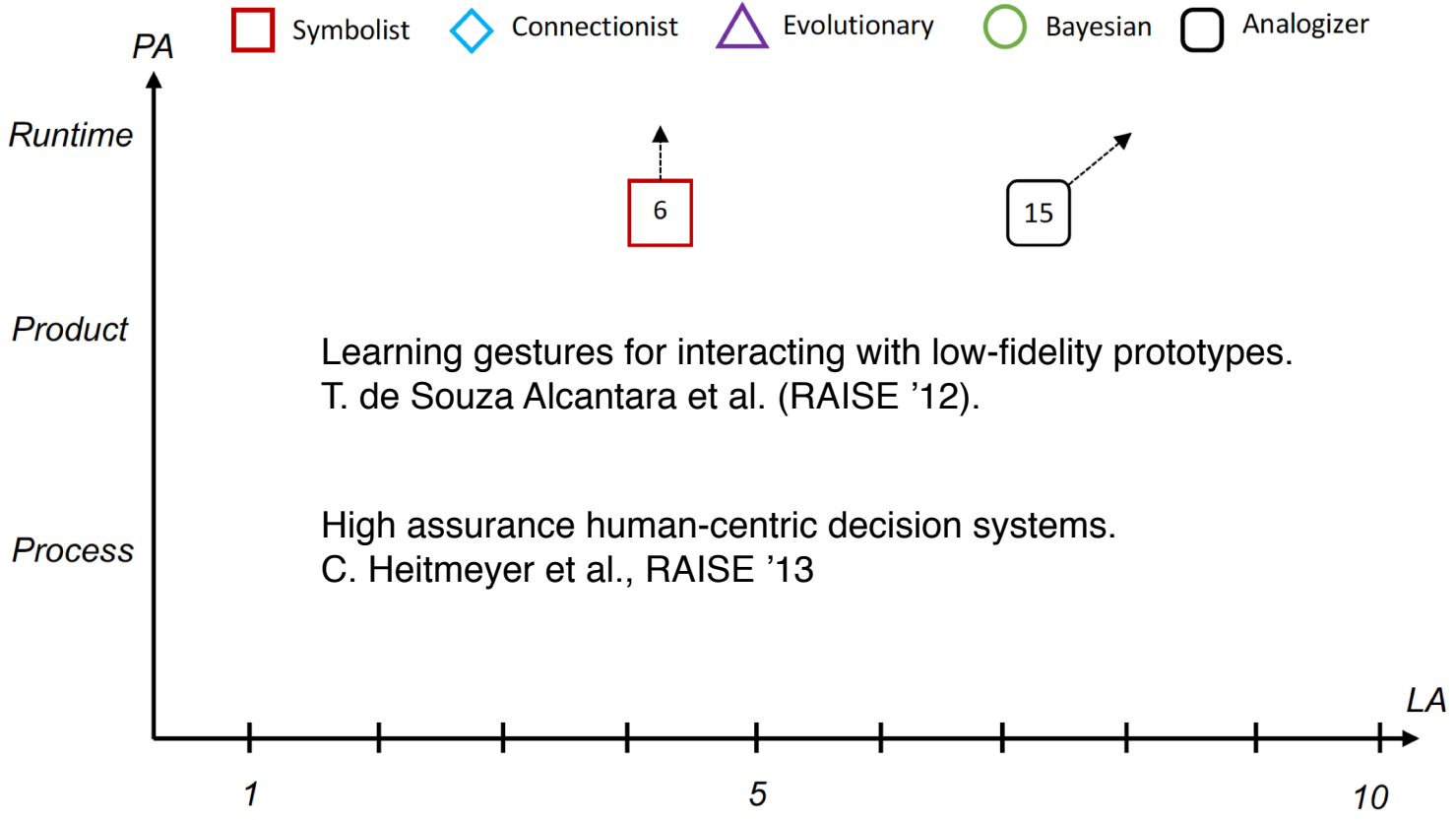
AI-SEAL Taxonomy: Utility demonstration

ID	Title	Year (Q1.2)
1	Automated Prediction of Defect Severity Based on Codifying Design Knowledge Using Ontologies	2012
2	Clone Detection Meets Semantic Web Based Transitive Closure Computation	2012
6	Learning Gestures for Interacting with Low-Fidelity Prototypes	2012
15	High Assurance Human-Centric Decision Systems	2013
34	Mining Enterprise Models for Knowledgeable Decision Making	2015
35	Text Understanding for Programming in Natural Language: Control Structure	2015
36	Clustering Source Code Elements by Semantic Similarity Using Wikipedia	2015
37	Black-Box Test Generation from Inferred Models	2015
38	Recommending Features and Feature Relationships from Requirements Documents for Software Product Lines	2015
40	Towards Interpretable Defect-Prone Component Analysis Using Genetic Fuzzy Systems	2015
41	Comparative Analysis of Predictive Techniques for Release Readiness Classification	2016
42	A Learning Algorithm for Change Impact Prediction	2016
43	Measuring the Principal of Defect Debt	2016
44	Topic Cohesion Preserving Requirements Clustering	2016
31	A self-learning approach for validation of communication in embedded systems	2014

AI-SEAL Taxonomy: Utility demonstration

ID	Reference	Appl. Point (PA)	Type of AI (TAI)	Level of Auto (LA)
#1	[26]	Process	Analogizer	2
#2	[27]	Process	Analogizer	4
#31	[32]	Process	Connectionist	7
#34	[38]	Process	Symbolist	9
#36	[39]	Process	Analogizer	2–3
#37	[37]	Process	Symbolist	2–3
#38	[23]	Process	Symbolist	2
#40	[13]	Process	Evolutionary	2–3
#41	[14]	Process	Analogizer	2–3
#42	[36]	Process	Analogizer	2–3
#43	[3]	Process	Analogizer	2–3
#44	[34]	Process	Analogizer	2–3
#6	[12]	Product	Symbolist	4
#15	[25]	Product	Analogizer	7
#35	[31]	Product	Symbolist	9
#6	[12]	$(\text{Runtime})_{\text{FW}}$	Symbolist	$(8)_{\text{FW}}$
#15	[25]	$(\text{Runtime})_{\text{FW}}$	Analogizer	7


Symbolist
Connectionist
Evolutionary
Bayesian
Analogizer
PA
Runtime
Product
Process
LA
1
5
10
6
15
35
37
42
40
44
38
43
36
1
41
2
31
34



Learning gestures for interacting with low-fidelity prototypes.
T. de Souza Alcantara et al. (RAISE '12).

High assurance human-centric decision systems.
C. Heitmeyer et al., RAISE '13

AI-SEAL Taxonomy: Limitations

- Manual classification (… so far)
- Some cases are harder than others:
  - Product vs. Runtime
  - AI technology
- Regardless, the triggered discussion is very insightful

Concluding remarks

- Become more aware and strategic before applying
  - Careful with the “hype of AI”
- Extensible in further levels:
  - Shape of artefact/source
  - Combinations of AI technology facet
- Bridges AI applications across different domains in SE

References

T. B. Sheridan. 1980. Computer control and human alienation. Technology review 83, 1 (1980), 60–73.

C. Heitmeyer, M. Pickett, L. Breslow, D. Aha, J. G. Trafton, and E. Leonard. 2013. High assurance human-centric decision systems. In RAISE ’13).
https://doi.org/10.1109/RAISE.2013.6615202

T. de Souza Alcantara, J. Denzinger, J. Ferreira, and F. Maurer. 2012. Learning gestures for interacting with low-fidelity prototypes. In RAISE ’12
https://doi.org/10.1109/RAISE.2012.6227967

J. Frohm. 2008. Levels of automation in production systems. Ph.D. Dissertation. Chalmers University of Technology, Gothenburg, Sweden.

P. Domingos. 2015. The master algorithm: How the quest for the ultimate learning machine will remake our world. Basic Books, NY, USA.

CHALMERS
UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF GOTHENBURG

Q&A

Robert Feldt,
Francisco Gomes de Oliveira Neto,
Richard Torkar

Software Engineering Division
Chalmers | University of Gothenburg
gomesf@chalmers.se

RAISE 2018, Gothenburg, Sweden