



# Computational Creativity

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The following video clips, pictures and audio files have been removed from this file to save space:

- Video: Poemcatcher tests "Brain Poetry" machine at Frankfurt Book Fair:  
<https://www.youtube.com/watch?v=cNnbTQL8jB4>
- Images produced by Deep Dream, see e.g.  
<https://en.wikipedia.org/wiki/DeepDream>
- Audio clip: music produced by a programme by Turing and his colleagues



# Remote Associates Test (RAT)

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- What word relates to all of these three words?
  - *coin*            – **silver** *coin*
  - *quick*           – *quick* **silver**
  - *spoon*           – **silver** *spoon*
- Measures the ability to discover relationships between remotely associated concepts
- A (controversial) psychometrical test of creativity
- Correlates with IQ and originality in brain storming



# Modeling RATs computationally

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- A single RAT question is a quadruple

$$r = (c_1, c_2, c_3, a)$$

- A probabilistic approach: find  $a$  that maximizes

$$P(a|c_1, c_2, c_3) \propto P(a, c_1, c_2, c_3)$$

- Maximize

$$P(a) \prod_{i=1}^3 P(c_i|a)$$

(cf. naïve Bayes)



# Modeling RATs computationally

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- Learn word frequencies from a large corpus
  - Use Google 1 and 2-grams to estimate probabilities  $P(a)$  and  $P(c_i|a)$
  - (Google n-grams: a large, publically available collection of word sequences and their probabilities)
- A lot more could be done, but we want to keep things as simple as possible
  - Creative behavior *without* an explicit semantic resource (such as WordNet)



# Modeling RATs computationally

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- Data: published psychometric RATs with 212 questions in total
- No preprocessing at all, alternatively just simple stop word removal
- Numbers of correct answers:

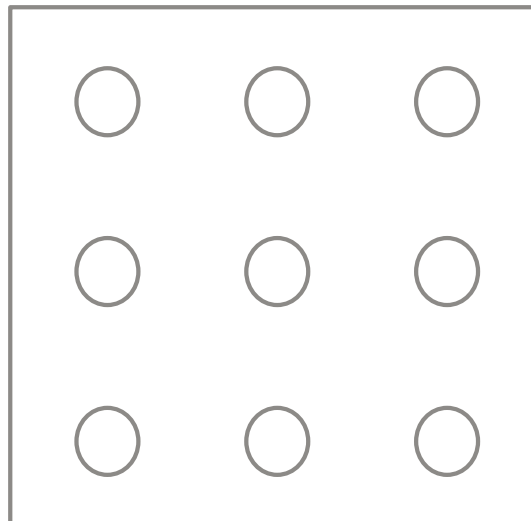
Humans [1]	Computer: 2-grams	Computer: 2-grams, stopwords removed	Computer: 2-grams, plurals removed	...
50%	54%	66%	?	?



# A test of creativity

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- Connect the nine dots with four straight lines without lifting the pen

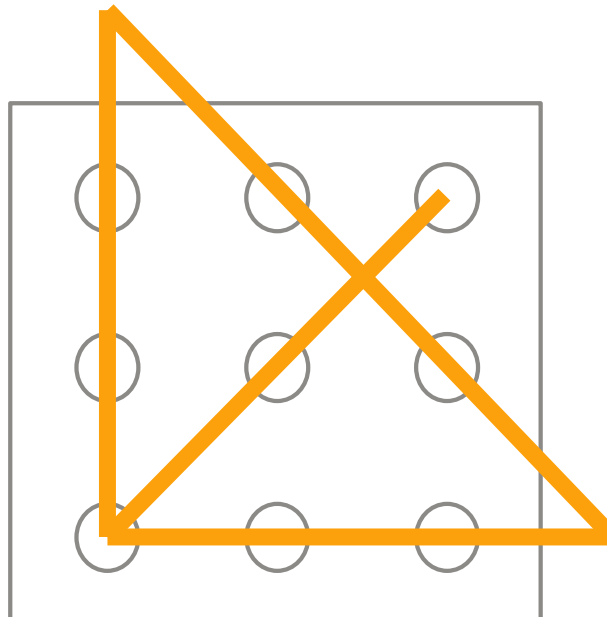




# A test of creativity

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- Connect the nine dots with four straight lines without lifting the pen







# Some key concepts of (computational) creativity



# Four Perspectives to Creativity

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**Producer**

**Process**

**Product**

**Press**

(MacKinnon, 1970; Rhodes, 1961)



# Defining creativity

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Producer  
Process  
**Product**  
Press

“Creativity is the ability to come up with ideas or artefacts that are *new*, *surprising* and *valuable*.”

- Boden 1992

➔ Computers are creative if they are able to come up with ideas or artefacts that are new, surprising, and valuable.



# Creativity vs. mere generation

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Two components of creativity:

- **Intentionality**: the system has a goal, and it is aware of the goal
- **Self-determinism**: the system can make decisions regarding its own behavior

Mere generation:

- "Just doing what one was told to do"
- (or was told to learn to do)

**Producer**

**Process**

**Product**

**Press**



”Electricity is ecological”

From Ping Xiao and Simo Linkola: Vismantic: Meaning-making with Images, ICCC 2015



## Music with an intent

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Produce music that depicts/”sonifies” the user’s sleep pattern (so the user can easily follow her sleep patterns and improve her sleep)

(Figures and audio clips removed from this file, see <http://www.sleepmusicalization.net>)



# Machine learning vs. creativity



# Machine Learning Problems vs. Creative Problems

Machine learning problems	Creative problems
<i>Well-specified</i> (e.g., "Learn to recognize faces in images")	<i>Ill-defined, open-ended</i> (e.g. "write a poem")
<i>Have obvious and objective success criteria</i> (e.g. recognition accuracy)	<i>Have subjective and non-explicit criteria</i> (e.g. when is a poem good?)
<i>Success can be measured with relative ease</i> (e.g. evaluate on test set)	<i>Evaluation cannot be computed easily</i> (e.g. ask subjects to evaluate)





# Uses of ML in Computational Creativity

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According to the four perspectives to creativity:

- **Producer:** learn skills, develop taste, model emotions or emotional responses, ...
- **Process:** use generative models, GANs etc., solve subtasks related to adaptivity, ...
- **Product:** recognize what is novel, predict the value of artefacts, ...
- **Press:** predict reactions; generate framings



# **Creatively self-adaptive software**

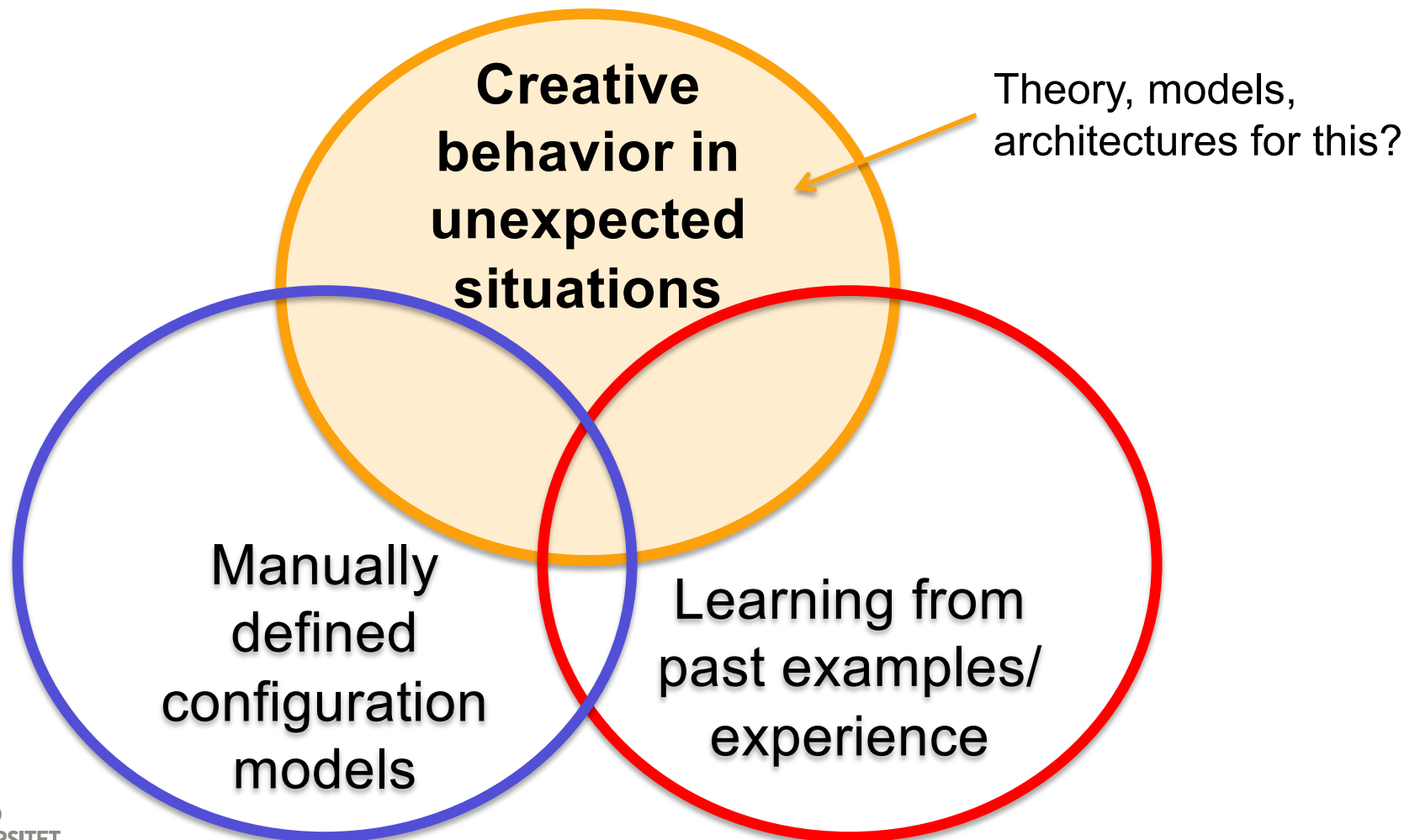
**A new research area**





# Creatively Adaptive Software

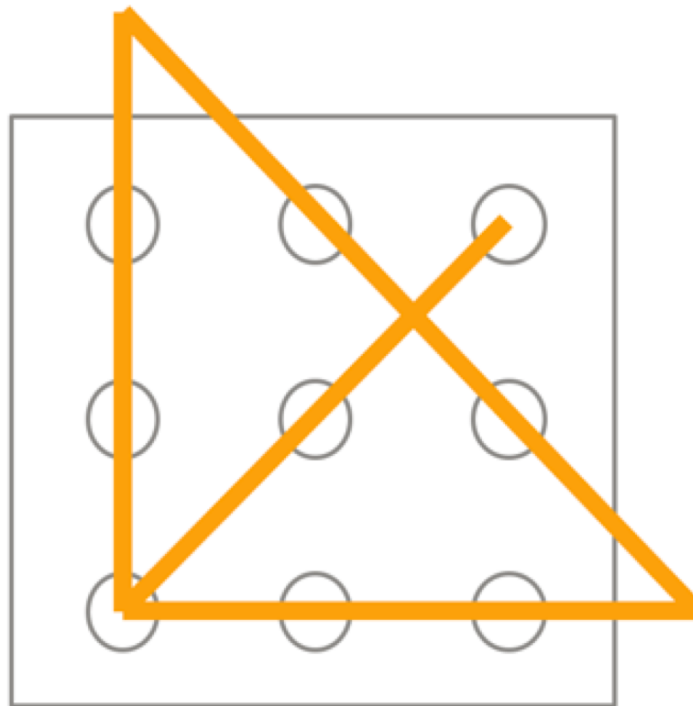
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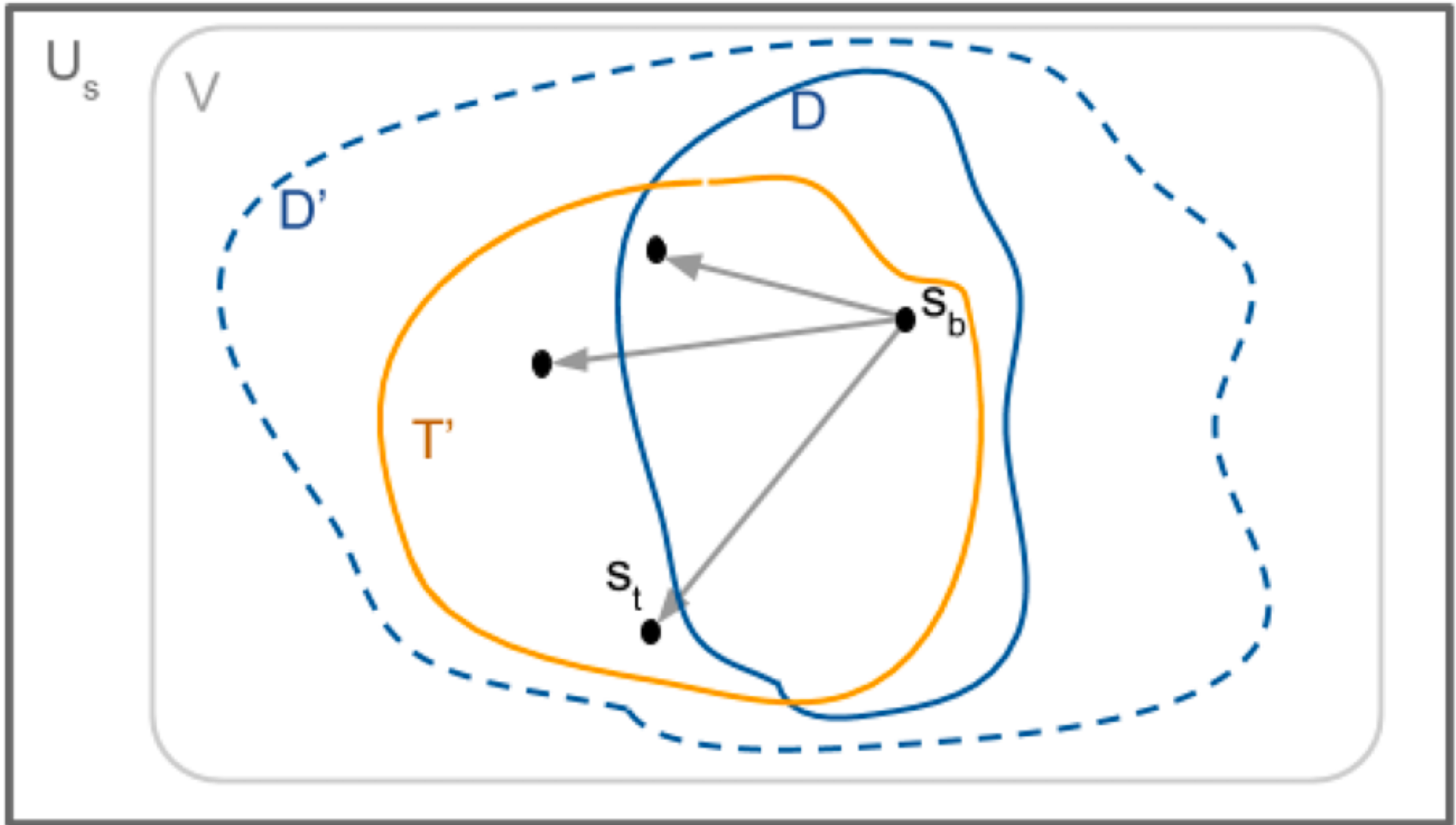




# How to design SW that can surprise (in a useful way)

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**Design of self-adaptive SW that affords novelty, surprise, value, intention and self-determinism**



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Goal awareness	The system's ability to recognize and reason about its own goals.
Context awareness	The system's ability to have knowledge of the external systems or objects interacting with it.
Domain awareness	The system's ability to interpret its domain knowledge.
Resource awareness	The system having knowledge of all the resources at its disposal.
Strategy awareness	The system's ability to comprehend the available adaptation strategies and their relevance to emerging adaptation needs.

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Enactor awareness	The system's ability to have knowledge of the available enactors and their collective competence.
Probe awareness	The system's ability to gain knowledge and control all available instrumentation.
Time awareness	The system's ability to keep history of events, such as interactions, activities, adaptations and contextual changes, exploiting the data for predicting future phenomena, e.g., usage patterns, failures, threats etc.
Hypothesis awareness	The system's ability to envision and assess adaptations that it has not implemented yet, that can improve its behaviour.

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# Conclusion



# Computational creativity:

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**Producer  
Process  
Product  
Press**

“the philosophy, science and engineering of computational systems which, by taking on particular responsibilities, exhibit behaviours that unbiased observers would deem to be creative”

- Colton and Wiggins 2012



# Thank you

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