



# How do Recent Machine Learning Advances Impact the Data Visualization Research Agenda?

*Timo Ropinski (Ulm, organizer),  
Daniel Archambault (Swansea), Min Chen (Oxford),  
Ross Maciejewski (Arizona), Klaus Mueller (Stony Brook),  
Alexandru Telea (Groningen), Martin Wattenberg (Google)*

## **The Space of Machine Learning**

**Min Chen, University of Oxford**

No “Political” Statement



# Machine Learning is

- A scientific subject
- A useful technology for some algorithm/software development
- Potentially a powerful paradigm for simulating cognitive functions
- But most machine learning processes are NP-processes

# Four Levels of Visualization

*typical search space*

## 1. Disseminative Level

- *This is “a”!*

$O(1)$

## 2. Observational Level

- *“a”, “b”, “c”, ... what, when, where?*

$O(n)$

## 3. Analytical Level

- *Are “a”, “b”, “c” related? Why?*

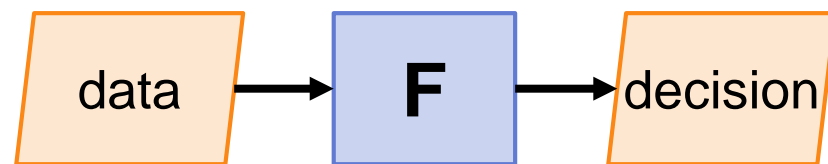
$O(n^k)$

## 4. Model-developmental Level

- *How does “a” lead to “b”?*

$O(k^n), O(n!)$

# Scientifically, ...



## The Space of All Functions

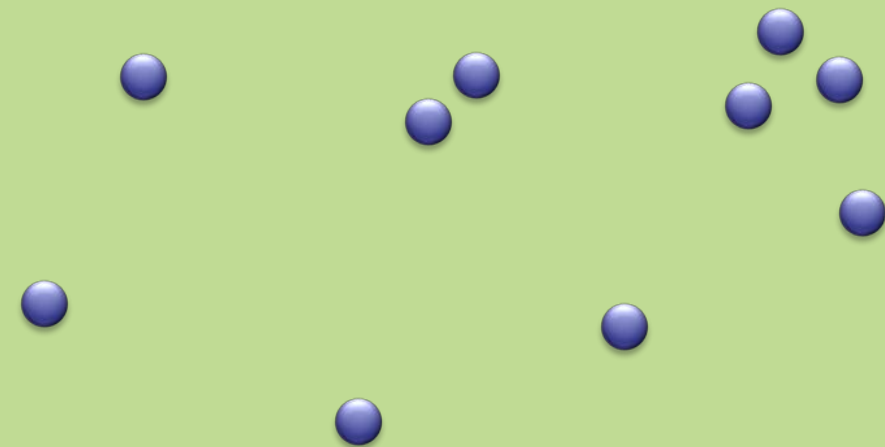
Quantum computing?

Bio-computing?

Cognition?

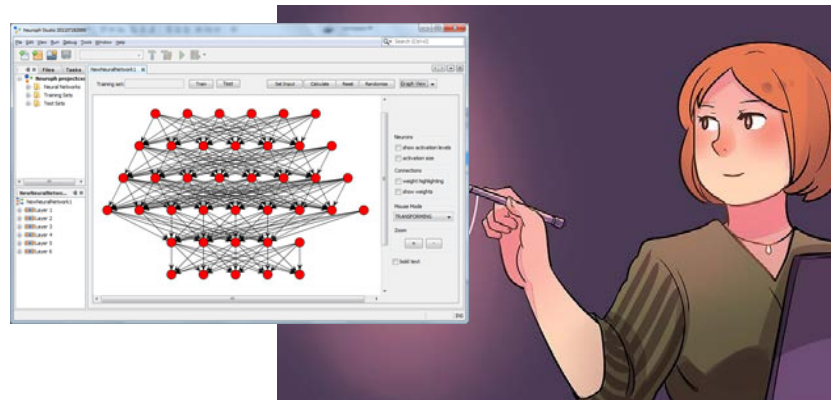
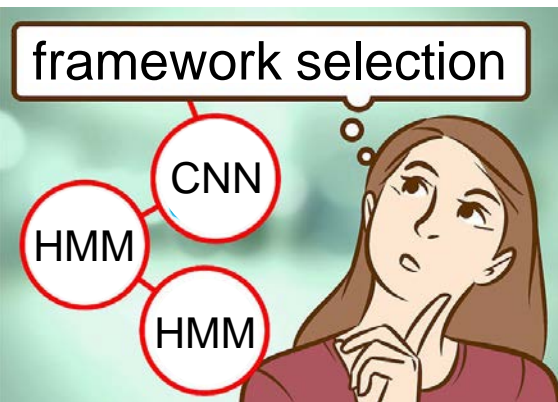
Social computing?

Universal Turing Machine  
(with infinite tape length)





# Scientifically, ...



## The Space of All Functions

Universal Turing Machine  
(with infinite tape length)

An ML framework  
with finite constructs



An ML  
Template

*not to scale*

# Scientifically, ...



Human  
Heuristics  
with finite  
resources

The Space of All Functions

Universal Turing Machine  
(with infinite tape length)

An ML framework  
with finite constructs

An ML  
Template

# My Observations

- **Algorithms: Some by humans, some by ML, some combined.**
- **Visually exploring the space of ML.**
  - *model space, template space, parameter space, data space, result space, and there relationships.*
- **Visually supporting software engineering with ML.**
  - *understanding, quality assurance, post-deployment monitoring.*



Modelling and simulating  
perceptual and cognitive functions  
that we use during visualization

# VIS2017 is a milestone for VIS+ML

- **Sunday:** Keynote 2, Keynote 3, VDS panel, best paper
- **Monday:** Vis+ML Tutorial, VADL 2017 workshop
- **Tuesday:** VAST best paper
- **Wednesday:** VAST Session ML1
- **Thursday:** VIS panel, VAST ML2, InfoVis Text+ML
- **Friday:** VAST ML3

# Machine Learning and Visualization

**Present**



**Past**



**Future**

