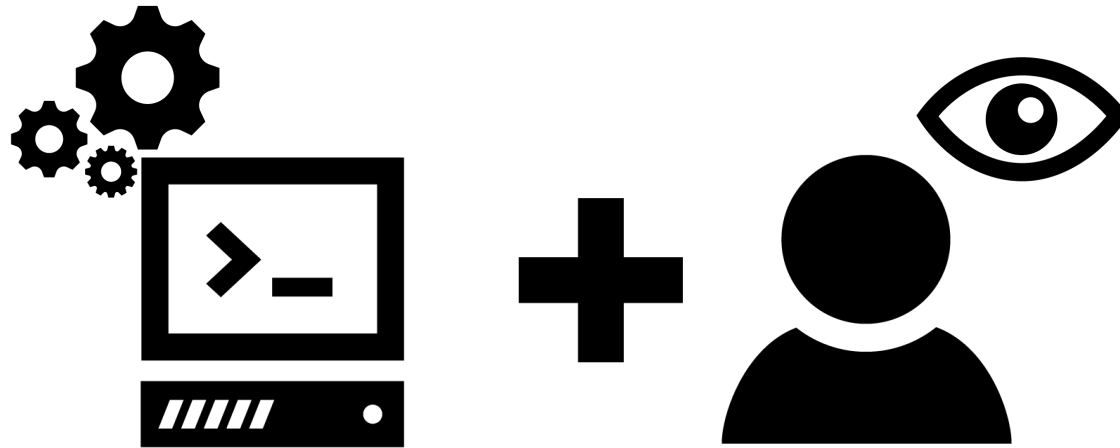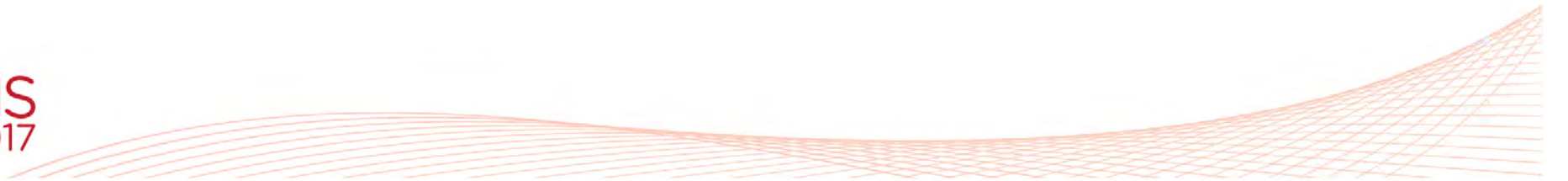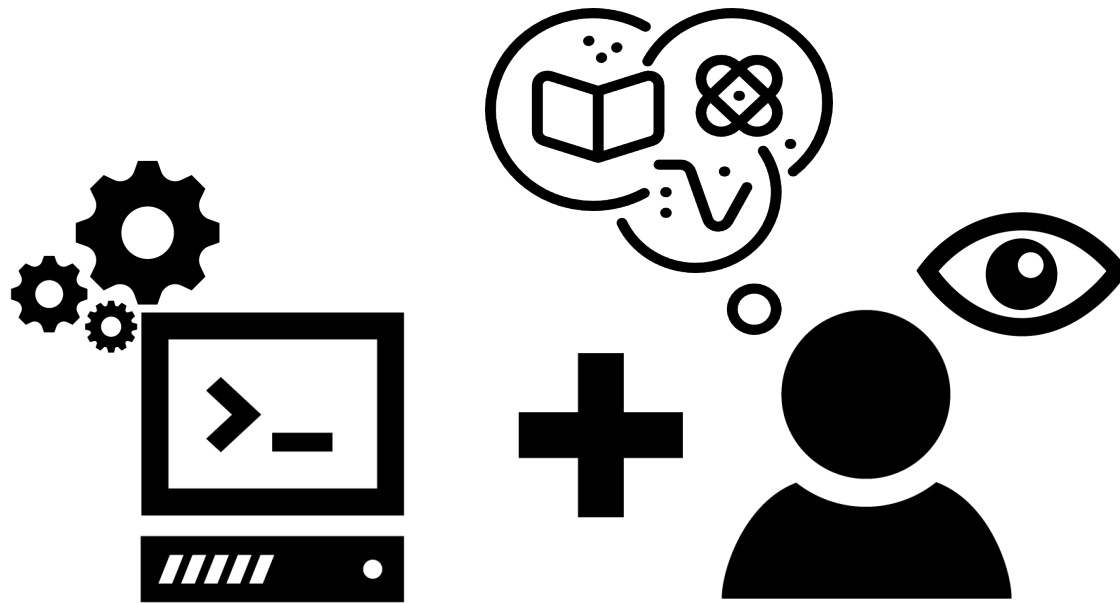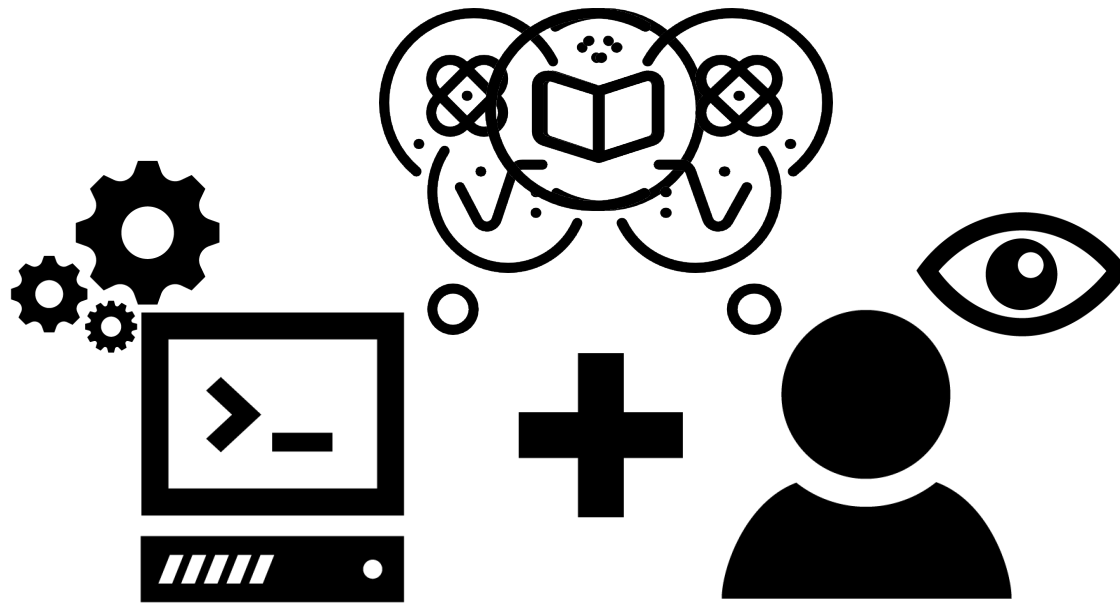**VIS 2017**

The role of explicit knowledge:
a conceptual model of knowledge-assisted visual analytics

Paolo Federico[1], Markus Wagner[12], Alexander Rind[12], Albert Amor-Amorós[1], Silvia Miksch[1], Wolfgang Aigner[12]

1 TU WIEN / CVAST

2 /fh/// st. pölten

Explicit Knowledge = "Data that represents
the results of a computer-simulated cognitive process,
such as perception, learning, association, and reasoning,
or the transcripts of some knowledge acquired by human beings"

[Chen et al., 2009]

Knowledge in Visualization

wisdom
knowledge
information
data

[Ackoff, 1989]

knowledge-assisted
visualization

[Chen M. et al., 2009]

tacit

explicit

[Wang, 2009]

knowledge-based
interfaces

[Pike et al., 2009]

domain

operational

[Chen C., 2005]

prior
knowledge
in the KDD
process

[Fayyad et al., 1996]

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Visualization Models

[van Wijk, 2005]

[Wang et al., 2009]

[Pirolli & Card, 2005]

[Sacha et al., 2014; Ribarsky & Fisher, 2016]

[Ceneda et al, 2017]
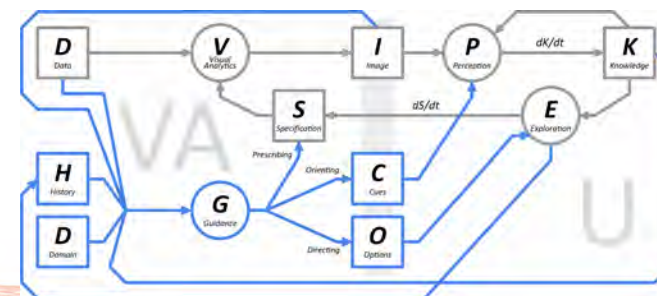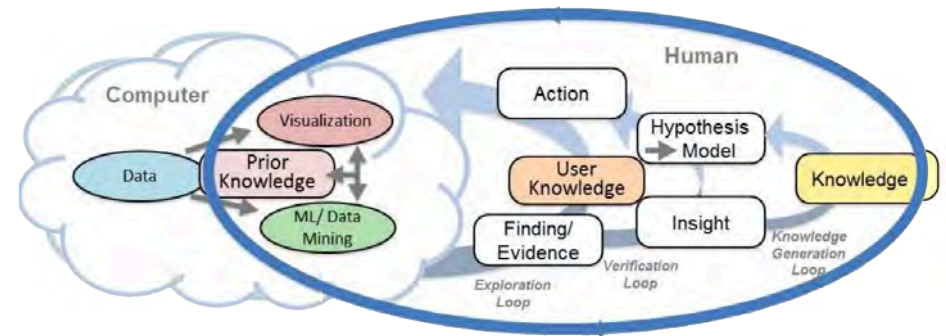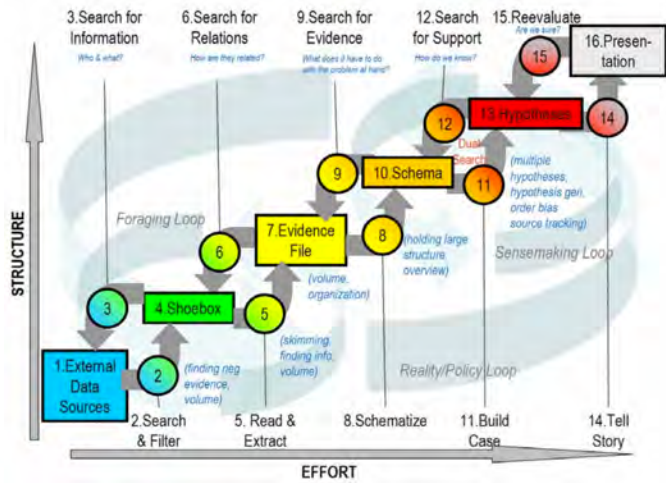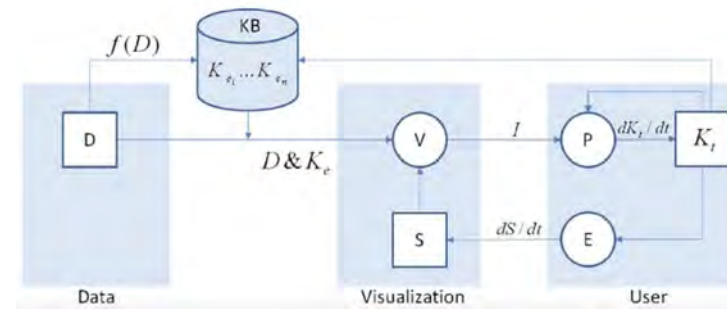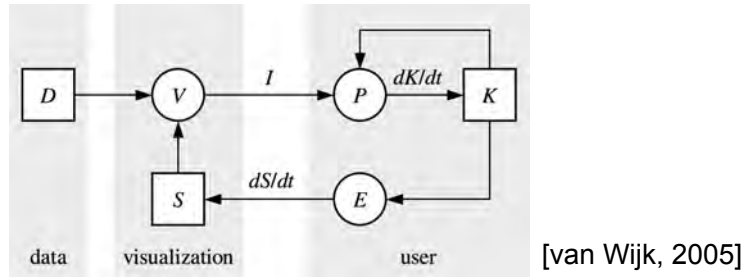
Model Criteria

- VA components

- Spaces

- Knowledge Types

- Knowledge Processes

Knowledge processes

- Generation
  - Visualization
  - Analysis

- Exploitation
  - Visualization
  - Intelligent Analysis
  - Guidance

- Transformation
  - Internalization
    - Knowledge Visualization
    - Simulation
  - Externalization
    - Direct Externalization
    - Interaction Mining

Generation: Visualization

$$D \rightarrow \boxed{V} \xrightarrow{I} \boxed{P} \rightarrow K^{\tau}$$

$$\uparrow$$

$$S$$
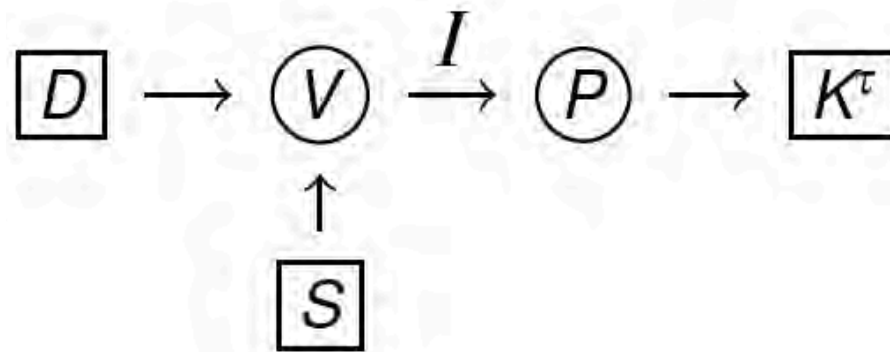
D	data
S	specification
K^{τ}	tacit knowledge
I	image
V	visualization
P	perception

Generation:
Automated Data Analysis
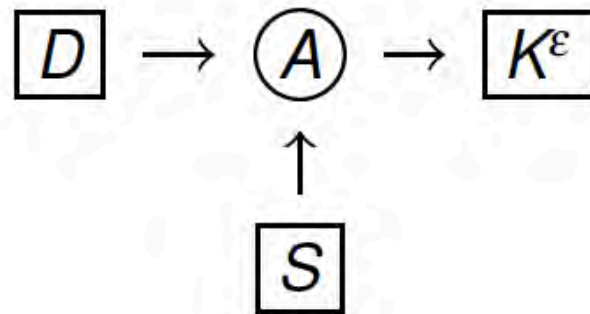
D	data
S	specification
K^τ	tacit knowledge
K^ε	explicit knowledge
I	image
V	visualization
P	perception
A	analysis

Transformation:
Internalization by Knowledge Visualization

$$K^\varepsilon \rightarrow V \xrightarrow{I} P \rightarrow K^\tau$$

D	data
S	specification
K^τ	tacit knowledge
K^ε	explicit knowledge
I	image
V	visualization
P	perception
A	analysis

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Transformation:
Internalization by Simulation
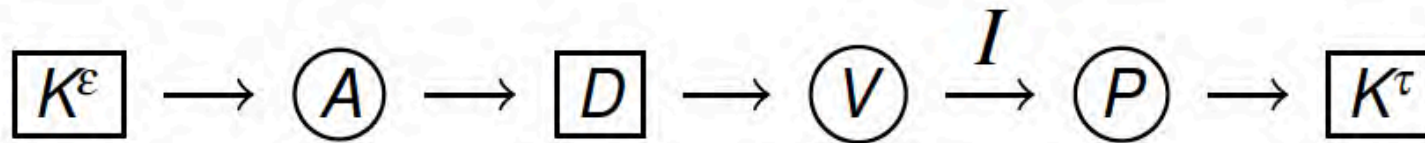
$$K^\varepsilon \rightarrow A \rightarrow D \rightarrow V \xrightarrow{I} P \rightarrow K^\tau$$

D	data
S	specification
K^τ	tacit knowledge
K^ε	explicit knowledge
I	image
V	visualization
P	perception
A	analysis
X	externalization
E	exploration

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Transformation:
Direct Externalization

$$K^\tau \rightarrow \boxed{X} \rightarrow K^\varepsilon$$
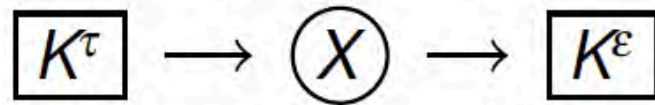
$\boxed{D}$	data
$\boxed{S}$	specification
$\boxed{K^\tau}$	tacit knowledge
$\boxed{K^\varepsilon}$	explicit knowledge
I	image
V	visualization
P	perception
A	analysis
X	externalization

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Transformation:
Externalization by Interaction Mining

$$K^\tau \rightarrow E \rightarrow S \rightarrow A \rightarrow K^\varepsilon$$

D	data
S	specification
K^τ	tacit knowledge
K^ε	explicit knowledge
I	image
V	visualization
P	perception
A	analysis
X	externalization
E	exploration

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Exploitation: Visualization

D	data
S	specification
K^τ	tacit knowledge
K^ε	explicit knowledge
I	image
V	visualization
P	perception
A	analysis
X	externalization
E	exploration

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Exploitation:
Intelligent Data Analysis
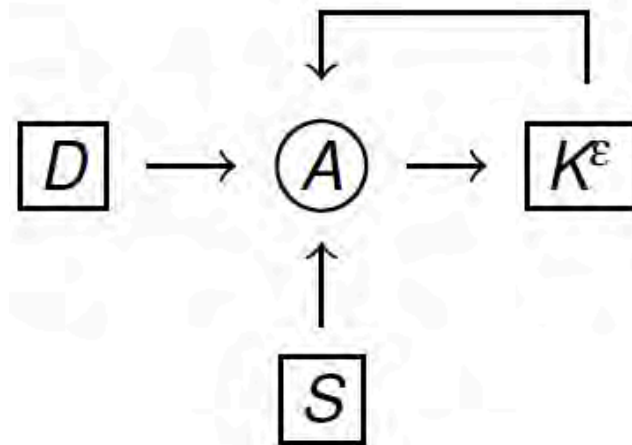
D	data
S	specification
K^{τ}	tacit knowledge
K^{ε}	explicit knowledge
I	image
V	visualization
P	perception
A	analysis
X	externalization
E	exploration

Exploitation: Guidance
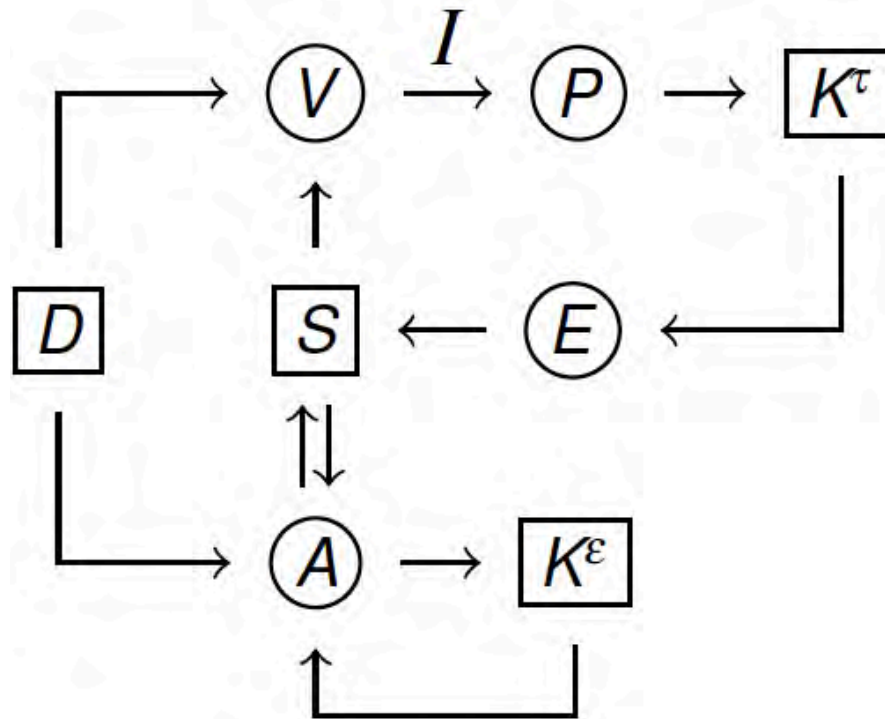
D	data
S	specification
K^τ	tacit knowledge
K^ε	explicit knowledge
I	image
V	visualization
P	perception
A	analysis
X	externalization
E	exploration

All processes

Characterizing Analysis
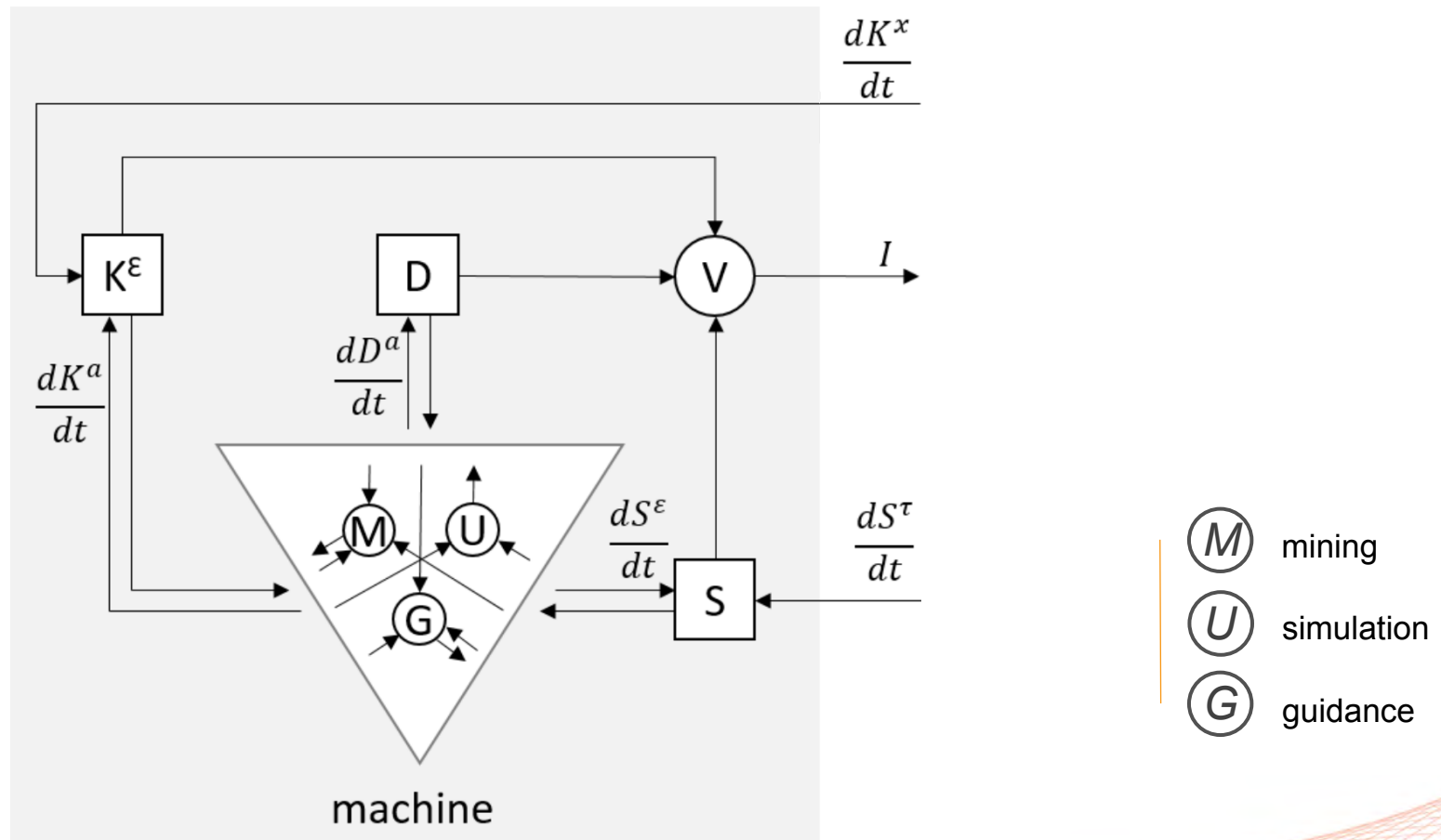
Characterizing Knowledge

Space	Type	Origin
Cognitive/Perceptual	Operational	Pre-design
Computational	Domain/Declarative	Design
	Domain/Procedural	Data
		Single User
		Multiple Users

Applying the model

|		Finding Waldo [13]	Knave/Visitors [48]	Smart Grids [67]	KEGS [79]	IMAGE [53]	Compliance [9]	EVE [11]	SemViz [36]	Compliance [5]	Kav-db [34]	Dabek et al. [27]	VisExemplar [63]	Prajna [69]	Bio ontology [16]	Qualizon Graphs [32]	SemTimeZoom [3,4]	Garg et al. [35]	Smart superviews [52]	DEL [12]	CareCruiser [38]	CareVis [2]	Nam et al. [55]	PORGY [73]	RuleBeneder [66]	VisPad [65]	Sport Events [25]	KAVAGait	VizAssist [10]	Kamsu et al. [44]	Gnaeus [33]	KAMAS [75]	FMVAS [54]
Process	Data Analysis: $D \to A \to K^\varepsilon$							•	•									•															
	Knowledge visualization: $K^\varepsilon \to V$									•					•	•	•			•	•	•	•	•	•	•	•	•	•		•	•	•
	Simulation: $K^\varepsilon \to A \to D$						•																	•	•						•		
	Direct externalization: $K^\tau \to X \to K^\varepsilon$							•					•				•	•						•	•	•	•	•	•			•	
	Interaction mining: $S \to A \to K^\varepsilon$	•										•	•	•											•					•	•	•	
	Intelligent data analysis: $(D, K^\varepsilon) \to A \to K^\varepsilon$		•	•			•		•					•				•		•						•	•			•	•	•	•
	Guidance: $K^\varepsilon \to A \to S$			•					•			•	•	•	•	•	•		•		•	•	•							•	•	•	•
Type	Operational	•						•	•		•	•	•	•					•				•			•	•			•	•		•
	Domain, declarative		•		•	•	•								•	•	•	•		•	•	•							•		•	•	•
	Domain, procedural			•	•	•					•										•	•	•		•	•		•	•		•		•
Origin	Pre-design		•	•		•	•								•	•	•			•	•	•	•					•			•		•
	Design				•			•	•					•	•	•	•		•										•				•
	Post-design, data																	•					•		•		•			•			
	Post-design, single user	•						•					•							•	•	•		•	•	•	•	•	•	•		•	•
	Post-design, multiple users										•	•							•														

Gnaeus

- Processes
  - Data Visualization
  - Knowledge Visualization
  - Simulation
  - Intelligent Data Analysis
  - Guidance
- Type
  - Domain, Declarative
  - Domain, Procedural
- Origin
  - Pre-design
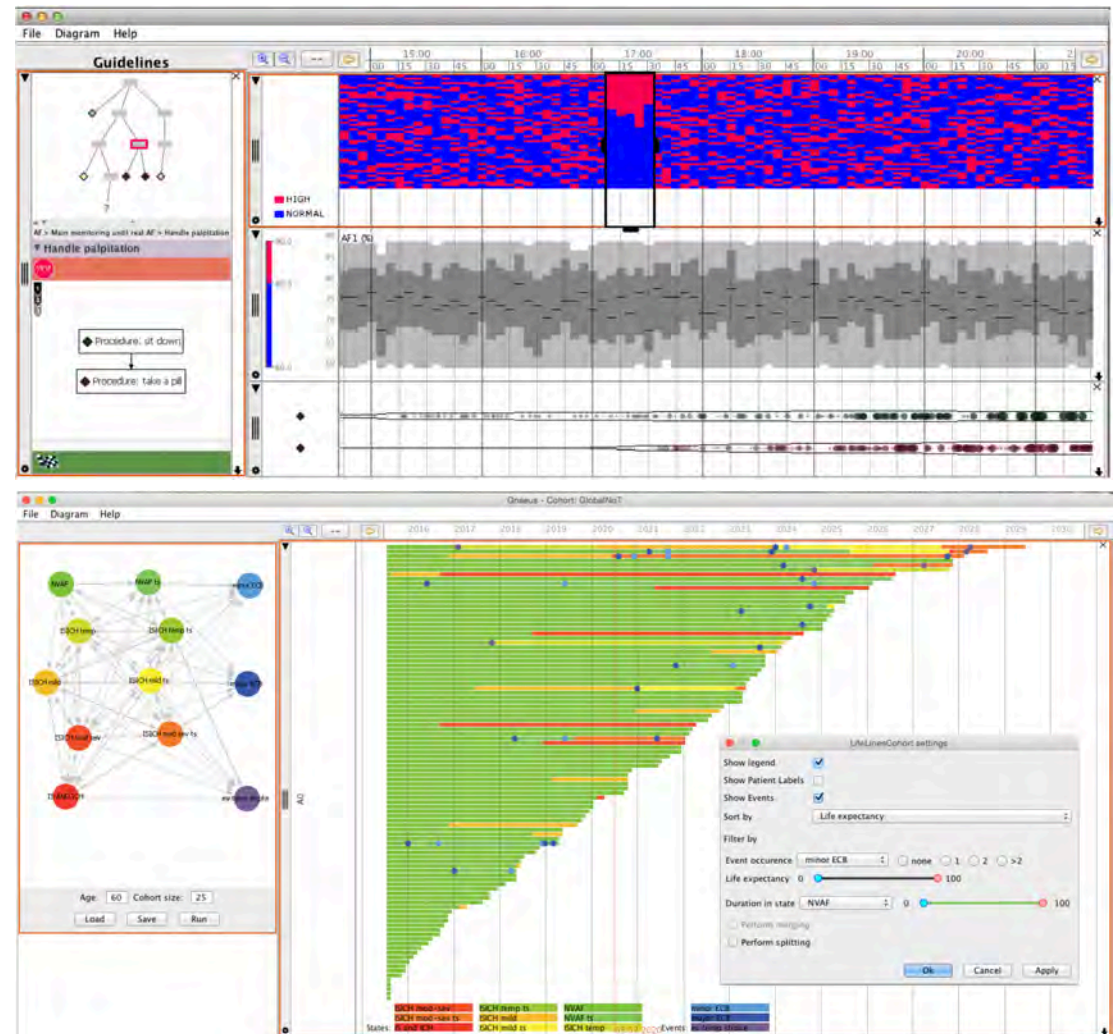
[Federico et al., 2015]

KAMAS

- Processes
  - Data Visualization
  - Knowledge Visualization
  - Direct Externalization
  - Intelligent Data Analysis
  - Guidance
- Type
  - Domain, Declarative
- Origin
  - Pre-design
  - Post-design, Single User
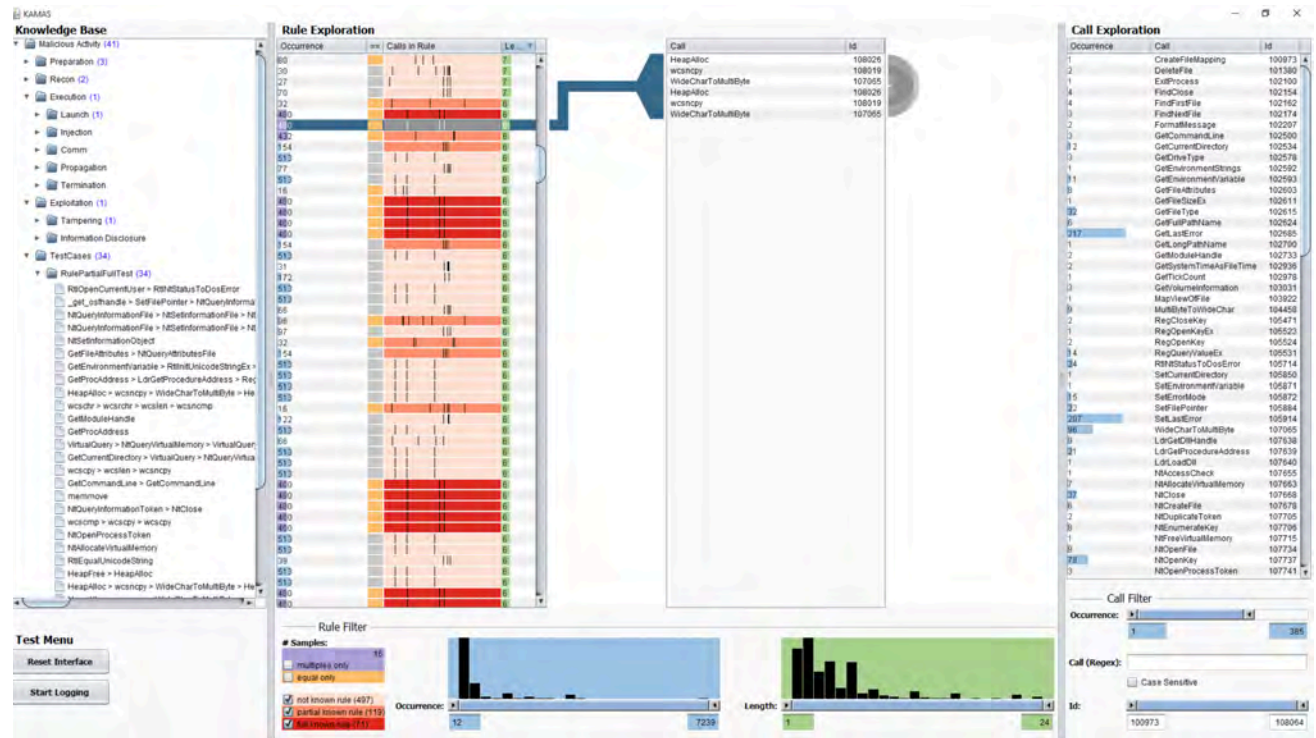
[Wagner et al., 2017]

The role of explicit knowledge:
a conceptual model of knowledge-assisted VA

- to describe and categorize existing approaches

- to asses existing systems in terms of costs/benefits

- to design new systems and inspire research directions