



The Ghost in the Machine - AI's Impact on Cultural Heritage (Research)

Prof. Dr. Harald Sack
IM/MATERIALITIES 2023
Torino, Nov 2023

The Ghost in the Machine

AI's Impact on Cultural Heritage (Research)

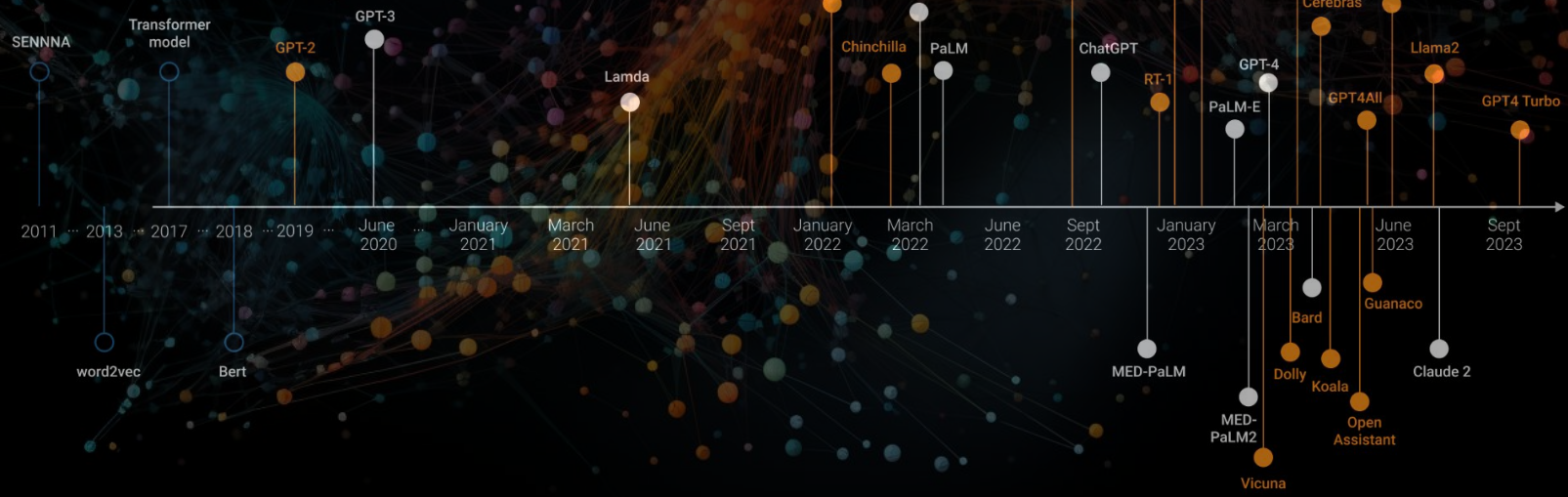
Outline:

1. **The Impact of Shifting this Presentation by a few Years**
2. **AI's Quantum Leap Forward**
 - **Linked Stage Graph and Visual Analysis**
3. **Large Language Models and the Art of Creative Hallucination**
4. **Hybrid AI**
 - **Iconclass Image Search and Image Classification**

The Impact of Shifting this Presentation by a few Years

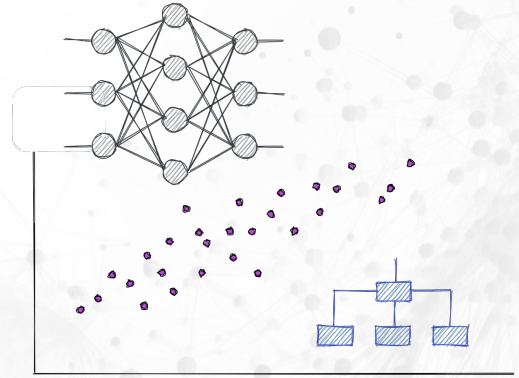
AI's Impact on Cultural Heritage (Research)

- Open Source Models
- Commercial Models
- Papers

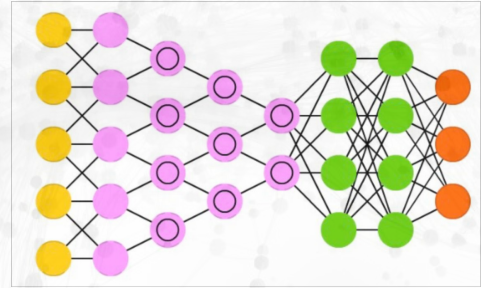


60+ Years of Machine Learning

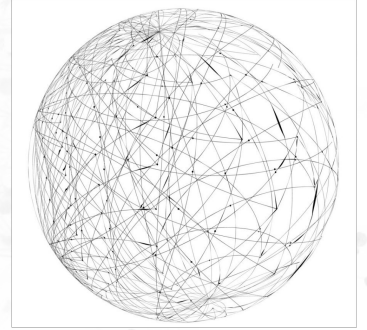
The Road to Large Language Models



Machine Learning



Deep Learning



Foundation Models

Emergence of ...

“How” (from examples)

“Features” (used for prediction) (advanced) “functionalities”

Homogenization of ...

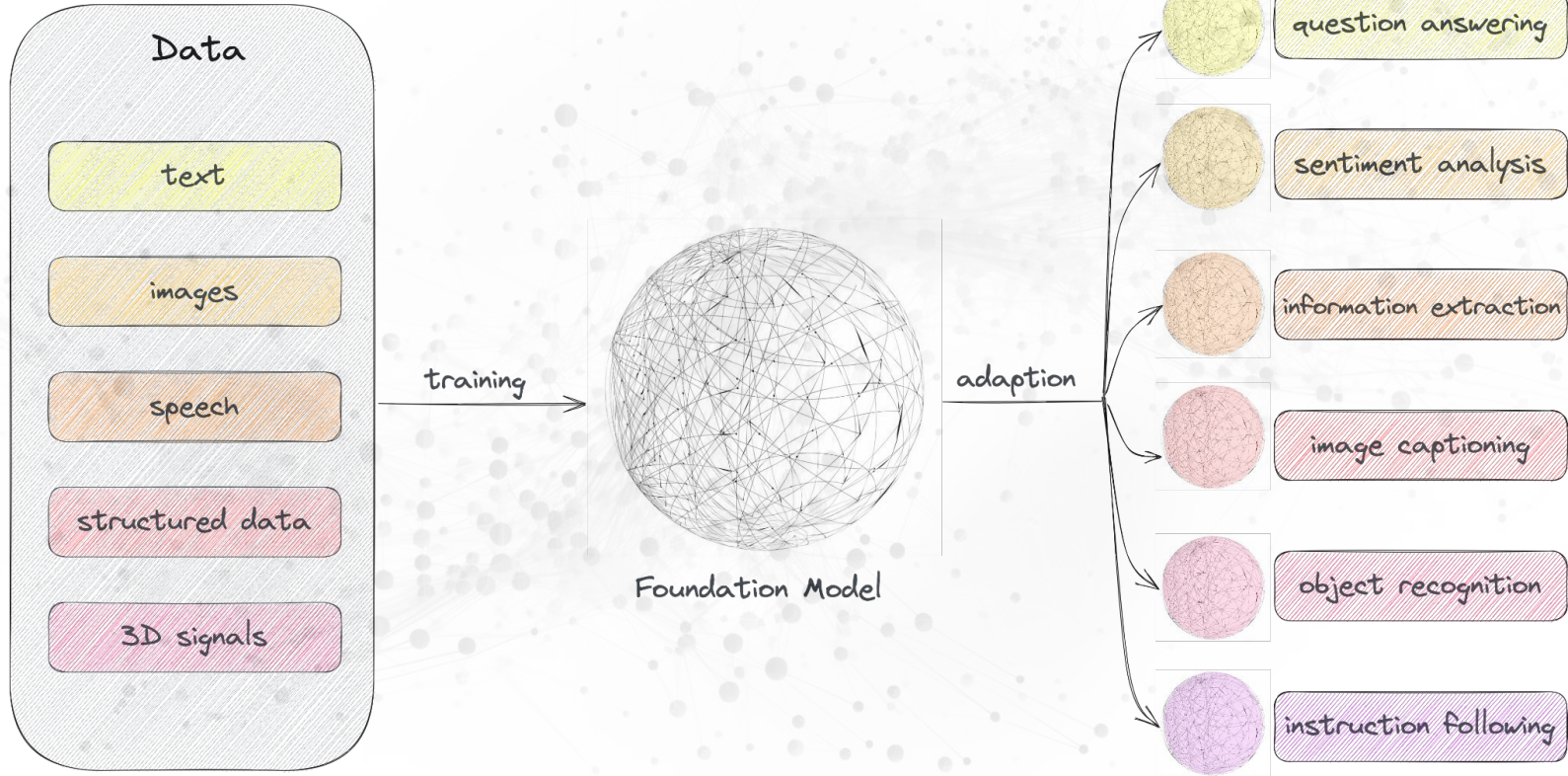
Learning Algorithms
(as e.g. logistic regression)

Model Architectures
(as e.g. CNNs)

Models
(as e.g. GPT-3/GPT-4)

Bommasani, Rishi, et al., *On the opportunities and risks of foundation models*. arXiv preprint arXiv:2108.07258, 2021.

The Advent of Foundation Models



Bommasani, Rishi, et al., *On the opportunities and risks of foundation models*. arXiv preprint arXiv:2108.07258, 2021.

From Deep Learning to Foundation Models

The Essential Factors for Success

- **Transfer Learning**

(Deep Learning) **Pretraining** the model for a surrogate task, **fine-tuning** of the model for a specific downstream task

- **Scale**

- Improvement of **computational power** (GPU throughput and memory)
- Development of **transformer model architecture** leveraging GPU parallelism enabling more expressive models
- Availability of **much more training data**

- **Self-supervised Learning**

Distributional semantics, autoregressive language models, Transformer based architectures, multimodality

From Basic to Bold in a few Years!

Example for AI's Quantum Leap Forward



From Basic to Bold in a few Years!

Example Linked Stage Graph

Example: Linked Stage Graph Image Annotation

- Knowledge Graph of Archival Documents and Photographies from Stuttgart State theatres 1890 - 1940
- Web page: <https://slod.fiz-karlsruhe.de/>

T. Tietz et al., *Linked Stage Graph*, in Proc. of the 15th Int. Conf. on Semantic Systems, 2019.

T. Tietz et al., *A Data Model for Linked Stage Graph and the Historical Performing Arts Domain*, In Proc. of the Int. Workshop on Semantic Web and Ontology Design for Cultural Heritage (SWODCH), 2023.



From Basic to Bold in a few Years!

Example Linked Stage Graph



PROBLEM:

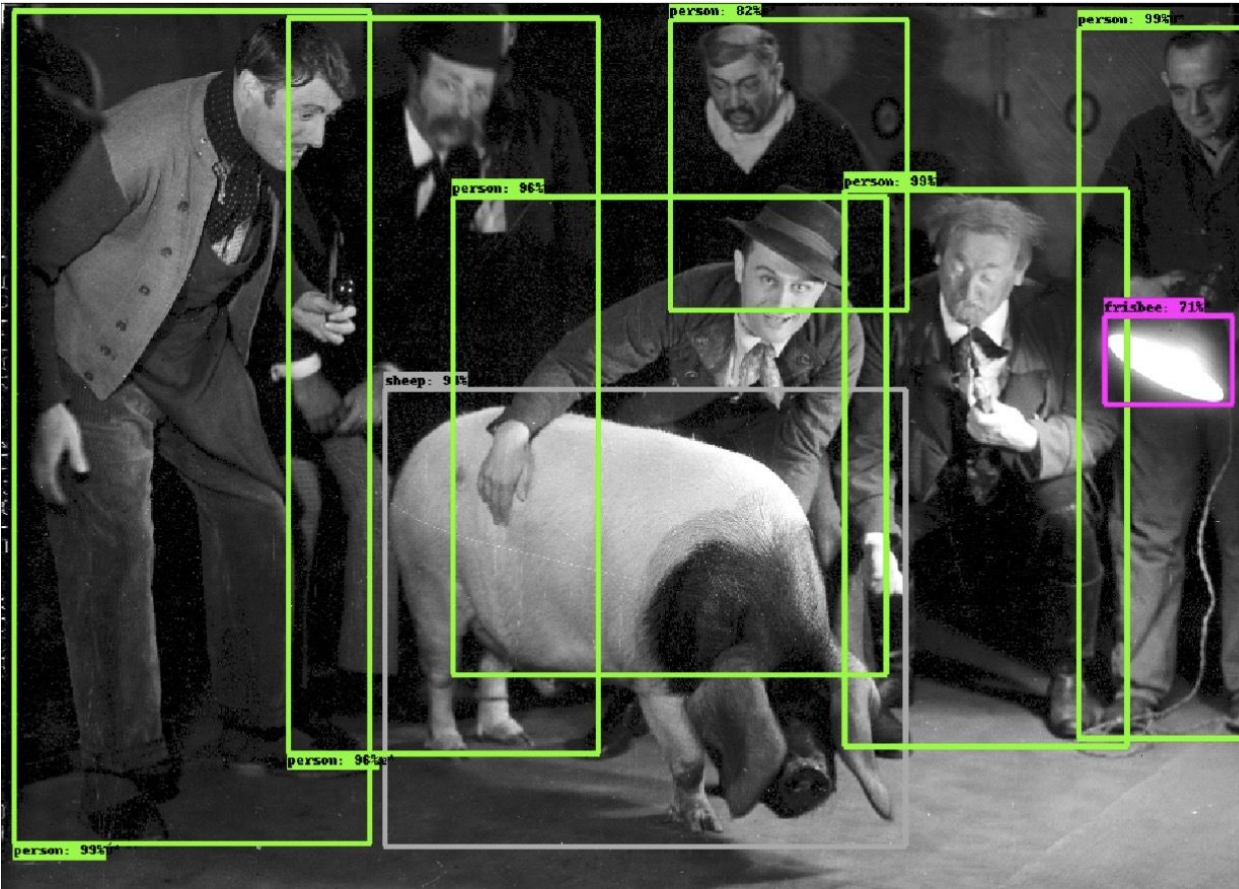
- No content-related Metadata or image descriptions available

SOLUTION:

- Visual Analysis:
 - Object Identification
 - Image Captioning

From Basic to Bold in a few Years!

Example Linked Stage Graph



Visual Analysis:

- Object Identification via denseNet-101 (2018)

Huang, G. et al, *Densely Connected Convolutional Networks*. arXiv 2018, arXiv:1608.06993.

From Basic to Bold in a few Years!

Example Linked Stage Graph



Visual Analysis:

- Image Captioning via prompt generation at Midjourney

Midjourney. 2022. Midjourney.com. <https://www.midjourney.com>



Midjourney Bot ✓ BOT 17.11.2023 16:24

1 a man is holding a pig in front of men, in the style of 1920s, spectacular show of ages, zeiss batis 18mm f/2.8, j. j. grandville, lively tableaus, flickr, viennese actionism --ar 128:75

From Basic to Bold in a few Years!

Example Linked Stage Graph



Visual Analysis:

- Image Captioning via prompt generation at Midjourney

Midjourney. 2022. Midjourney.com. <https://www.midjourney.com>



Midjourney Bot ✓ BOT 17.11.2023 16:24

1 a man is holding a pig in front of men, in the style of 1920s, spectacular show of ages, zeiss batis 18mm f/2.8, j. j. grandville, lively tableaux, flickr, viennese actionism --ar 128:75

2 a group of men holding a pig, and a camera, in the style of spectacular show of ages, associated press photo, whirly, low speed film, lively tableaux, soft-edged --ar 128:75

The Ghost in the Machine

Large Language Models and the Art of Creative Hallucination

GALACTICA

demo

Try: what is the schrodinger equation

Generate

Explore



Yann LeCun

@ylecun



A Large Language Model trained on scientific papers.

Type a text and [galactica.ai](#) will generate a paper with relevant references, formulas, and everything.

Amazing work by [@MetaAI](#) /
[@paperswithcode](#)



GALACTICA

demo

Try: what is the schrodinger equation

Generate

Explore



GALACTICA

wiki article on Hanlon's razor



Generated document for query "wiki article on Hanlon's razor"

x not verified

Hanlon's razor

Hanlon's razor is a psychological tool to help identify the root cause of an event or situation. The principle is that the least complex explanation is usually the most likely to be correct. It was named after its creator, the Canadian psychiatrist Thomas J. Hanlon, who first described it in 1977.

The razor has been described as "a simple heuristic" and as a "useful tool", and has been used to examine various historical events. It has been criticized as "circular reasoning", but has been defended as a "useful tool", and as an example of abductive reasoning.

Hanlon's razor



From Wikipedia, the free encyclopedia



This article **may be expanded with text translated from the corresponding article in French.** [show]

(April 2021) Click [show] for important translation instructions.

Hanlon's razor is an **adage** or **rule of thumb** that states "**never attribute to malice that which is adequately explained by stupidity.**"^[1] Known in several other forms, it is a **philosophical razor** that suggests a way of eliminating unlikely explanations for human behavior. It is probably **named after** Robert J. Hanlon, who submitted the statement to *Murphy's Law Book Two* (1980).^[1] Similar statements have been recorded since at least the 18th century.

Contents [hide]

- [Origin](#)
- [Other variations of the idea](#)
- [See also](#)
- [References](#)

Origin [edit]

A similar quotation appears in **Robert A. Heinlein's** novella *Logic of Empire* (1941).^[2]

The character "Doc" in Heinlein's story described the "devil theory" fallacy, explaining,

"You have attributed conditions to villainy that simply result from stupidity."^[3]



The Court of Foolishness of [Gerard de Lairesse](#). The accused, pursued by Hatred, is led by Calumny, Envy and Perfidy before a judge with donkey ears, surrounded by Ignorance and Suspicion.

Playground

- Completion
- Q & A
- Summarization

Advanced Settings

(or use our [jumpstart](#))

Model ⓘ
Multilingual model trained on English, German, French, Spanish and Italian

Maximum Tokens ⓘ

Stop Sequences ⓘ

Best of ⓘ

Show Probabilities ⓘ

Temperature ⓘ

Top K ⓘ

Prompt Text Multimodal

Q: Why is there war in Ukraine?
A:

Interpretative questions or Evaluative questions might be subject of inherent bias (of the training data).

Completion

The war in Ukraine is a result of the US-NATO-EU-backed coup in Ukraine in 2014. The coup was carried out by a coalition of fascist, neo-Nazi, and ultra-nationalist groups that have been operating in Ukraine for years. They are known as the Right Sector. The

[Append to Prompt](#)

[Reset](#)

[Submit](#)

The Ghost in the Machine

Symbolic Knowledge Representation to the Rescue

Limitations

You should be aware of the following limitations when using the model (including the demo on this website):

- **Language Models can Hallucinate.** There are no guarantees for truthful or reliable output from language models, even large ones trained on high-quality data like Galactica. **NEVER FOLLOW ADVICE FROM A LANGUAGE MODEL WITHOUT VERIFICATION.**
- **Language Models are Frequency-Biased.** Galactica is good for generating content about well-cited concepts, but does less well for less-cited concepts and ideas, where hallucination is more likely.
- **Language Models are often Confident But Wrong.** Some of Galactica's generated text may appear very authentic and highly-confident, but might be subtly wrong in important ways. This is particularly the case for highly technical content.

<https://cs.nyu.edu/~davise/papers/ExperimentWithGalactica.html>

Symbolic AI

- Knowledge Representation
- Reasoning
- Verification

Subsymbolic AI

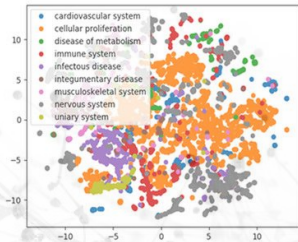
- Neural Networks, Deep Learning & Foundation Models

Hybrid AI
Models

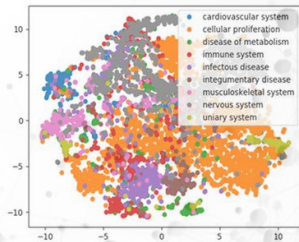
Hybrid AI - Combining Symbolic and Subsymbolic AI

Knowledge Graph Embeddings

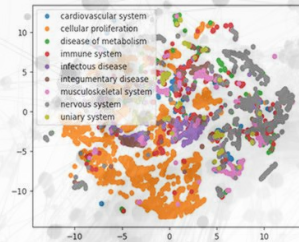
A. Walking_RDF/OWL



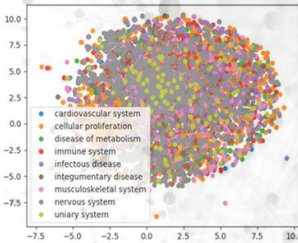
B. TransE embeddings



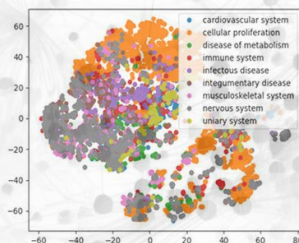
C. Poincare embeddings



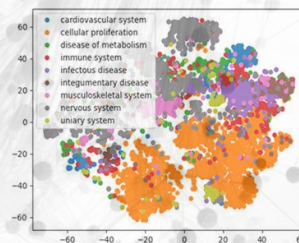
D. Rescal embeddings



E. Simple embeddings



F. R-GCN embeddings



- Knowledge Graph Completion
- KGE for Classification Tasks

- Ontology Mapping
- Entity/Knowledge Graph Alignment

R. Biswas et al.: MADLINK: Attentive Multihop and Entity Descriptions for Link Prediction in Knowledge Graphs, Semantic Web Journal, 202

G. A. Gesese et al.: RAILD: Towards Leveraging Relation Features for Inductive Link Prediction, IJCGC 2022

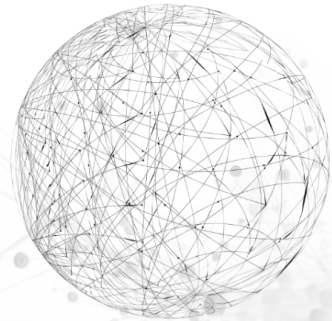
G. A. Gesese et al. A Survey on Knowledge Graph Embeddings with Literals: Which model links better Literal-ly?, Semantic Web Journal, 12(4), 2020

R. Biswas et al.: It's All in the Name: Entity Typing Using Multilingual Language Models, ESWC 2022

<https://peeri.com/articles/cs-341/>

Hybrid AI - Combining Symbolic and Subsymbolic AI

Explainability and Fact Checking



Foundation Model



Assertions



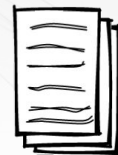
knowledge mapping



Knowledge Graph & Ontologies



path discovery
inconsistency detection
constraint validation



"verified" assertions

From Basic to Bold in a few Years!

Another Example for AI's Progress



From Basic to Bold in a few Years!

Example Iconclass

Example: Iconclass-based Image Classification and Multimodal Image Search

- Classification system for art and iconography with 28.000+ concepts
- Web page: <https://iconclass.org/>

C. Santini et al., *Multimodal Search on Iconclass using Vision-Language Pre-Trained Models*. JCDL 2023, pp. 285-287
E. Posthumus, et al.: *The Art Historian's Bicycle Becomes an E-Bike*. VISART @ ECCV 2022

4 · Society, Civilization, Culture

47 · crafts and industries

471 · agriculture, cattle-breeding, horticulture, flowerculture, etc.

4712 · cattle-breeding, livestock industry

47121 · cattle

471212 · pig

471212(+9) · pig (+ zoological aspects of domestic cattle and poultry)

📁 **471212(+95)** 📁 pig (+ animal(s) in motion; positions, expressions of animals)

Search with these related keywords:

animal, breeding, cattle, cattle-breeding, civilization, craft, culture, domestic animal, farm, farmer, hoofed animal, industry, occupations, pig, society

Add more detail:

471212(+951) · pig (+ fighting animals; aggressive relations)

471212(+952) · pig (+ movements of animal(s))

471212(+953) · pig (+ postures, positions of animal(s))

471212(+954) · pig (+ postures of the head ~ animal)

471212(+955) · pig (+ postures of forelegs, forepaws, claws of animal(s))

471212(+956) · pig (+ postures of hind leg(s) of animal(s))

471212(+957) · pig (+ morphology of expression of animal(s) (in general))

471212(+958) · pig (+ relations with neutral or friendly, non-aggressive character (expressive connotations ~ animals))



Traditional Iconclass Search

Syntactic Text-based Search

[Browse](#)

[Search](#)

pig

[Advanced Search](#)

[Include keys \(+\)](#)

[Sort by notation](#)

Found 97 results, searching for *pig*

All

[1](#)

[2](#)

[3](#)

[4](#)

- [11H\(BLAISE\)521](#) [the poor woman brings the pig's head](#)
- [11H\(BLAISE\)1](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: little boy, pig's head, wool-comb - specific aspects ~ male saint](#)
- [11H\(BLAISE\)13](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: candles, little boy, pig's head, wool-comb - male saint as patron](#)
- [11H\(BLAISE\)9](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: little boy, pig's head, wool-comb - portrait of male saint](#)
- [11H\(BLAISE\)11](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: little boy, pig's head, wool-comb - male saint as patron, post-mortem occurrence](#)
- [11H\(BLAISE\)8](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: little boy, pig's head, wool-comb - post-mortem occurrence](#)
- [11H\(BLAISE\)4](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: crossed candles, little boy, pig's head, wool-comb - non-miraculous activities and events ~ male saint](#)
- [11H\(BLAISE\)2](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: crossed candles, little boy, pig's head, wool-comb - early life of male saint](#)
- [11H\(BLAISE\)0](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: crossed candles, little boy, pig's head, wool-comb - male saint represented in a group](#)
- [11H\(BLAISE\)83](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: crossed](#)

1 - Religion and Magic

11 - Christian religion

11H - saints

11H(...) - male saints (with NAME)

[11H\(BLAISE\)](#) [the martyr Blaise \(Blasius\), bishop of Sebaste; possible attributes: crossed candles, little boy, pig's head, wool-comb](#)

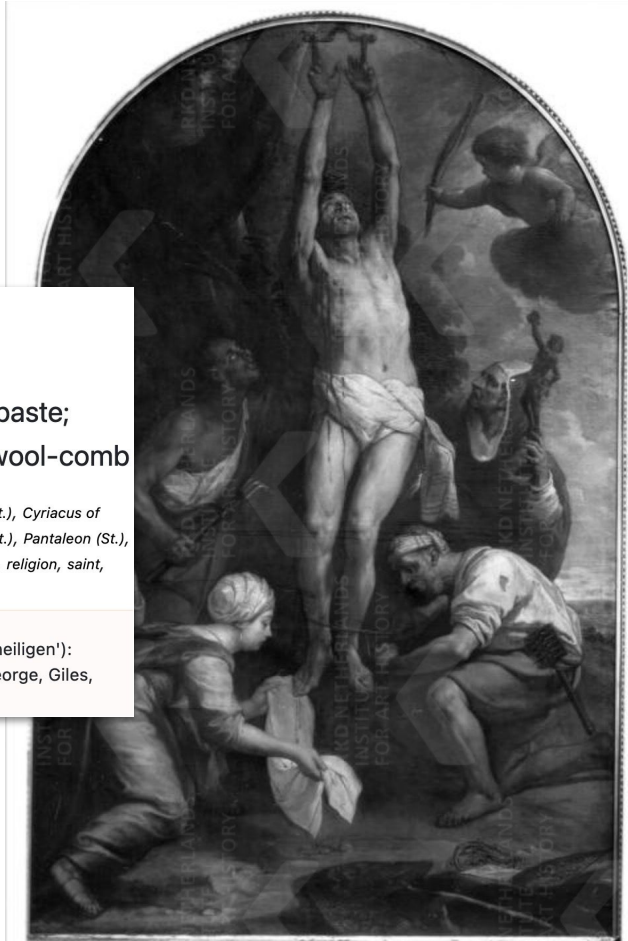
Search with these related keywords:

Achatius (St.), Barbara (St.), Blaise (St.), Catherine of Alexandria (St.), Christian religion, Christopher (St.), Cyriacus of Rome (St.), Denis (St.), Erasmus (St.), Eustace (St.), George (St.), Giles (St.), Holy Helpers, Margaret (St.), Pantaleon (St.), Vitus (St.), bishop, boy, candle, comb, crossed candles, fourteen, hackle, help, martyr, pig, pig's head, religion, saint, supernatural

Also see:

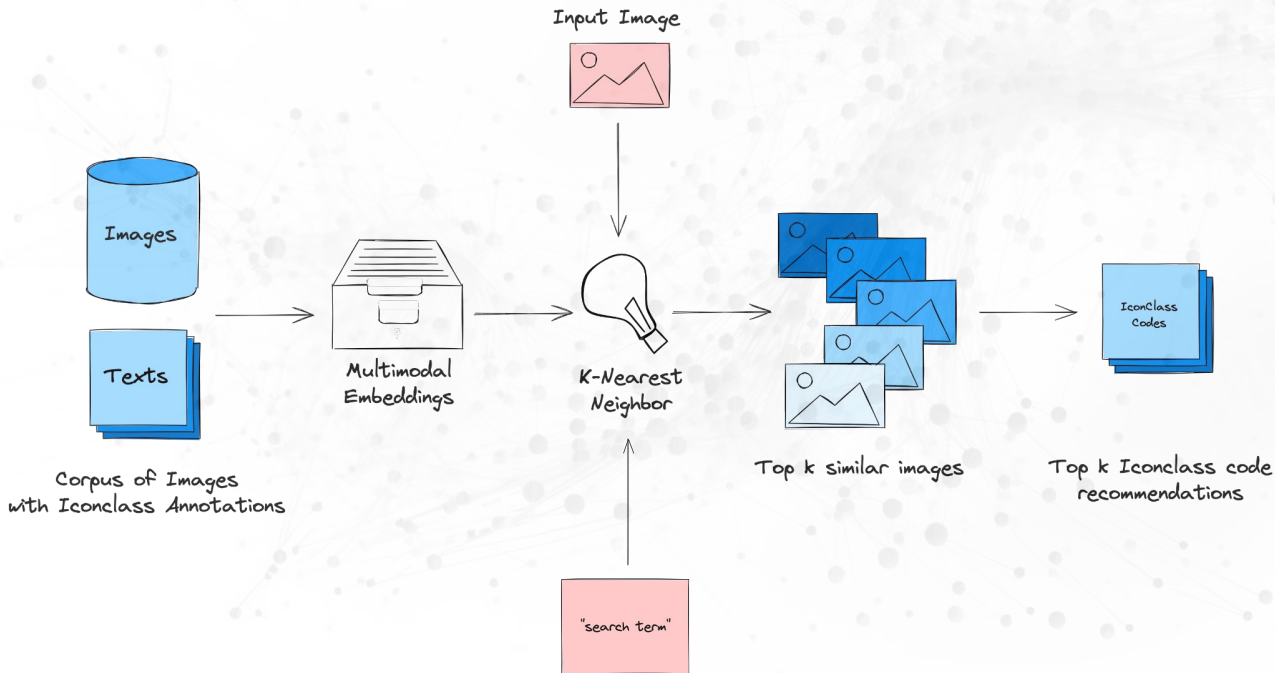
11H(FOURTEEN HOLY HELPERS) · group of fourteen auxiliary saints together ('Vierzehnheiligen'):

Achatius, Barbara, Blaise, Catherine, Christopher, Cyriacus, Denis, Erasmus, Eustace, George, Giles, Margaret, Pantaleon, Vitus



Iconclass Image Search and Classification

Iconclass Multi-Label Multi-Class Classification



Iconclass Image Search and Classification

Iconclass Multi-Label Multi-Class Classification

Advanced Search

Exclude keys (+)

Sort by notation

Found 26 results, searching for *this uploaded image*

- 44G33 torture
- 25H landscapes
- 11H(BLAISE) the martyr Blaise (Blasius), bishop of Sebaste; possible attributes: crossed candles, little boy, pig's head, wool-comb
- 11H saints
- 11G angels
- 73D6 the crucifixion of Christ: Christ's death on the cross; Golgotha (Matthew 27:45-58; Mark 15:33-45; Luke 23:44-52; John 19:25-38)
- 73D642 crucified Christ with Mary Magdalene, who usually weeps and embraces the cross
- 73D631 the centurion confessing his belief in Christ; sometimes the soldiers do the same
- 73D625 bystanders at the foot of the cross, among whom Mary, Mary Magdalene and John the Evangelist; Mary may be shown swooning
- 73 New Testament
- 73E77 the assumption of Mary ('assumptio corporis'): she is borne into heaven by angels
- 73D6411 Mary and John close together; sometimes Mary swooning ~ crucified Christ
- 73D61 comprehensive representations of the events on Golgotha during Christ's hanging on the cross, no particular event emphasized
- 73D6271 one of the soldiers (Stephaton) gives Christ vinegar on a sponge attached to a pole or lance
- 44G321(CROSS) instruments of torture, execution or punishment: cross
- 11H(GEORGE)6 martyrdom, suffering, misfortune, death of St. George



Iconclass Image Search and Classification

Similarity-based Image Search



Iconclass Image Search and Classification

Similarity-based Image Search

Browse

Search

Type some word(s) in English to search for and press 'Enter'...



Advanced Search

Exclude keys (+)

Sort by notation

Found 27 results, searching for *this uploaded image*

- 61B(+55) historical persons (portraits and scenes from the life) (+ full length portrait)
- 48C24 piece of sculpture, reproduction of a piece of sculpture
- 48C23 portrait, self-portrait of sculptor
- 48B11(+32) workshop, studio of the artist (in general) (+ sculpture)
- 41D2333 wooden shoes, clogs
- 31A2422 head turned to the right
- 31A231 standing figure
- 25F animals
- 47I2271 stall, stable
- 47I212 pig
- 41C nutrition, nourishment
- 34B232 fowl (cock, hen, chicken, etc.)
- 43B7 zoo (as place of recreation)



The Ghost in the Machine - AI's Impact on Cultural Heritage (Research)

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*Thank you very much for your
Attention!*

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Bibliography:

- [1] Bommasani, Rishi, et al., *On the opportunities and risks of foundation models*. arXiv preprint arXiv:2108.07258, 2021.
- [2] Zhou, Ce, et al., *A comprehensive survey on pretrained foundation models: A history from BERT to ChatGPT*. arXiv preprint arXiv:2302.09419, 2023.
- [3] T. Tietz et al., *Linked Stage Graph*, in Proc. of the 15th Int. Conf. on Semantic Systems, 2019.
- [4] T. Tietz et al., *A Data Model for Linked Stage Graph and the Historical Performing Arts Domain*, SWODCH2023, 2023.
- [5] Huang, G. et al, *Densely Connected Convolutional Networks*. arXiv 2018, arXiv:1608.06993.
- [6] Taylor, R., et al., *Galactica: A large language model for science*, arXiv preprint arXiv:2211.09085, 2022.
- [7] C. Santini et al., *Multimodal Search on Iconclass using Vision-Language Pre-Trained Models*. JCDL 2023, pp. 285-287.
- [8] E. Posthumus, et al., *The Art Historian's Bicycle Becomes an E-Bike*. VISART @ ECCV 2022.