CAT in the box:

A CausalAI – Tsetlin Machine Duo

Enabling explainable Stroke Diagnosis and Prevention

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Presenter

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EXPLAINABILITY 2025

Meet the team

PhD in Physics
Bio-optics and photonics

Post-docs
Microscopic Heat Engine
Light-Sheet Microscopy

Happy place
Sci-Fi and Fantasy books

Our Mosaic:
PhD in computer science
AI Engineers
R&D project management

Our Projects

DAMIS

Advanced remote management system for operational efficiency in water distribution networks through intelligent systems

PREV-ICTS

Clinically supported stroke scenario recognition, visualization, inference and simulation platform

DETECT

Automated technical detection and labeling in industrial engine technical diagrams using computer vision

SMARTQAM

New advanced QA testing platform using autonomous AI and full coverage

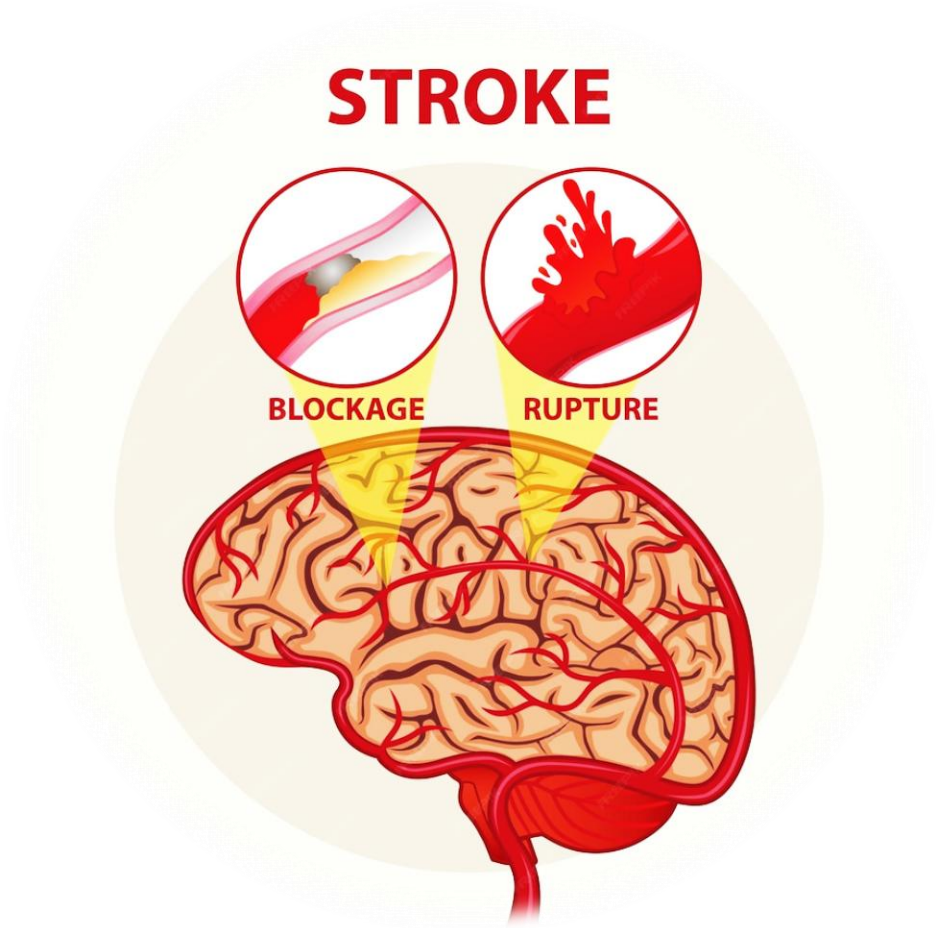
RIVER EU

New AI for a more resilient and sustainable steel supply chain

Outline

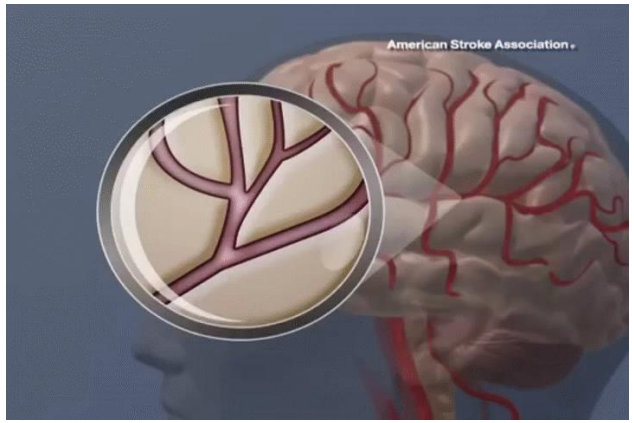
Introduction | Approach | Results | What's next? | Conclusion

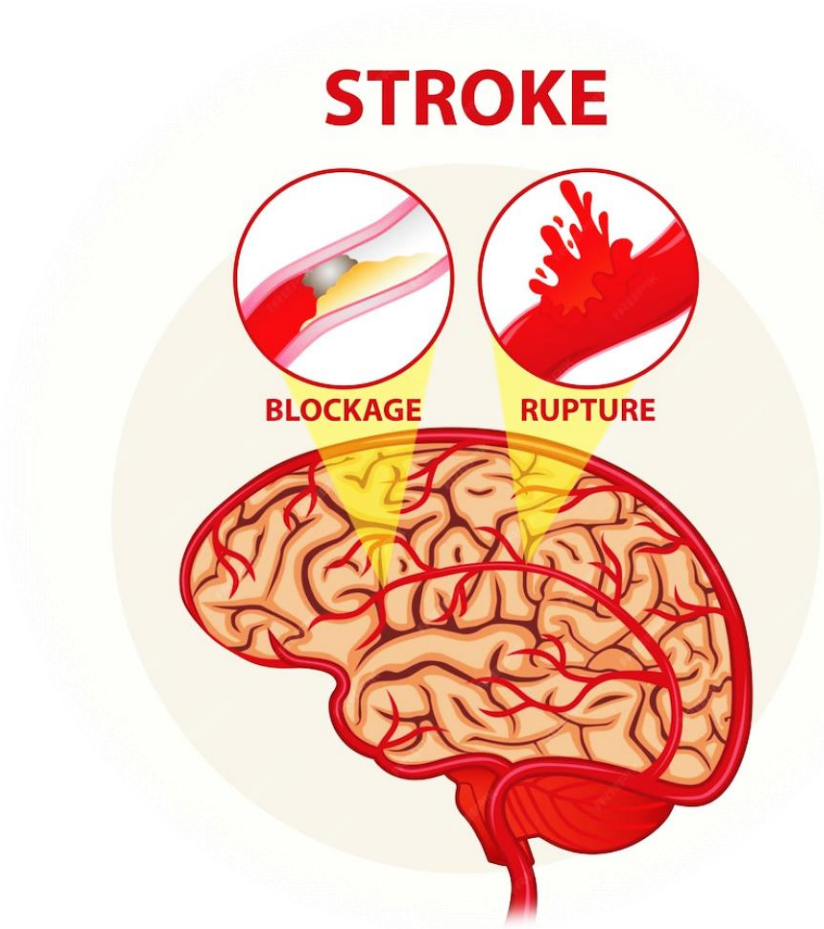
Alteration of blood supply to the brain



Alteration of blood supply to the brain

Ischemic
~87% of all strokes





Haemorrhagic
~10-15% of all strokes

Introduction

As per World Stroke Organisation,

- ✓ 2nd leading cause of death
- ✓ $890 billion annually
  - ✓ $1 trillion by 2030

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In Spain,

Estimated 35% increase in 10 years

1 in 5 have recurrent stroke

Our goal is to understand,

1. What contributes to stroke possibility?

2. Can we derive prevention strategies?
   - Influence of specific biomarkers

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1. What contributes to stroke possibility?
   - **Causal AI** – not just correlations!

2. Can we derive prevention strategies?
   - Influence of specific biomarkers
   - Rule based learning model – Tsetlin Machine

If A and not B, then class X

The ladder of causation

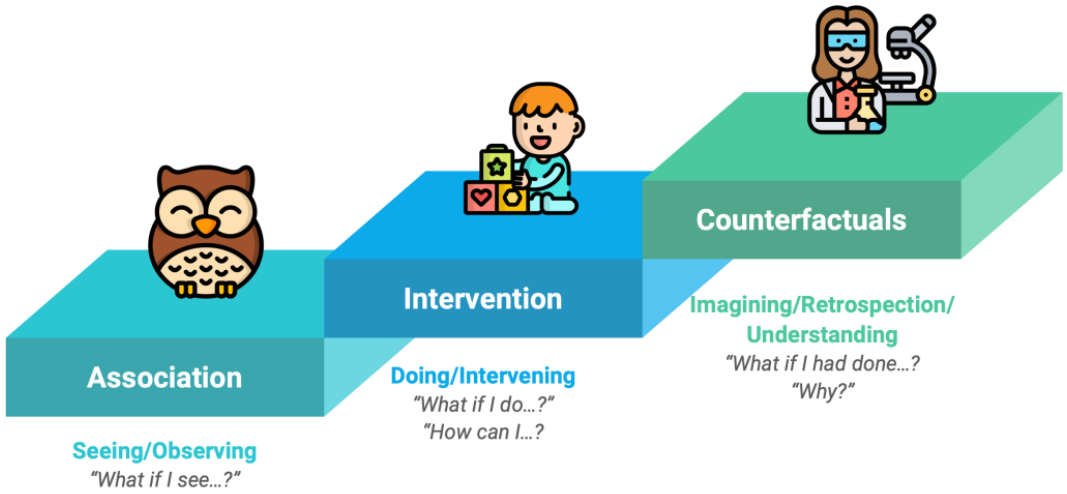
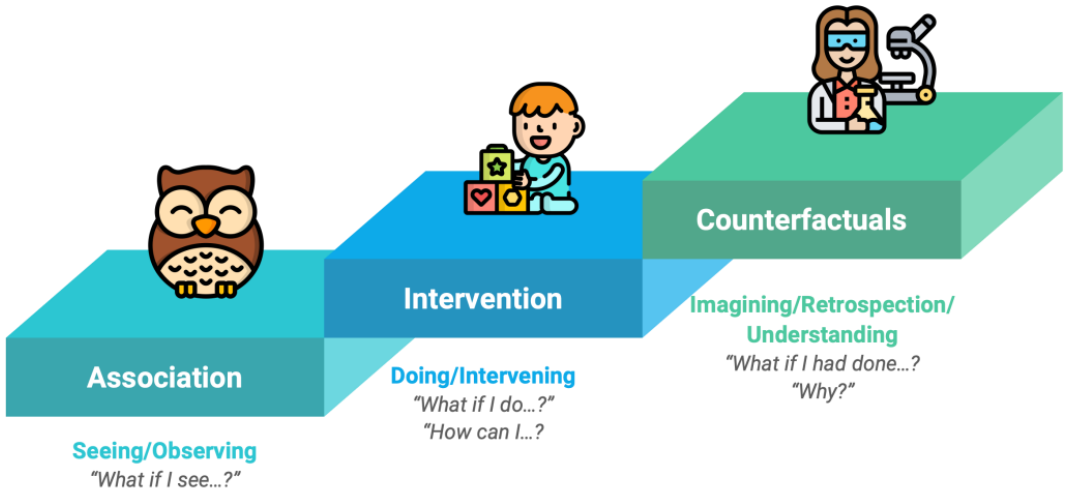


Image by Esra Simsek (based on Pearl's Ladder of Causation)

The ladder of causation



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Tsetlin Machine

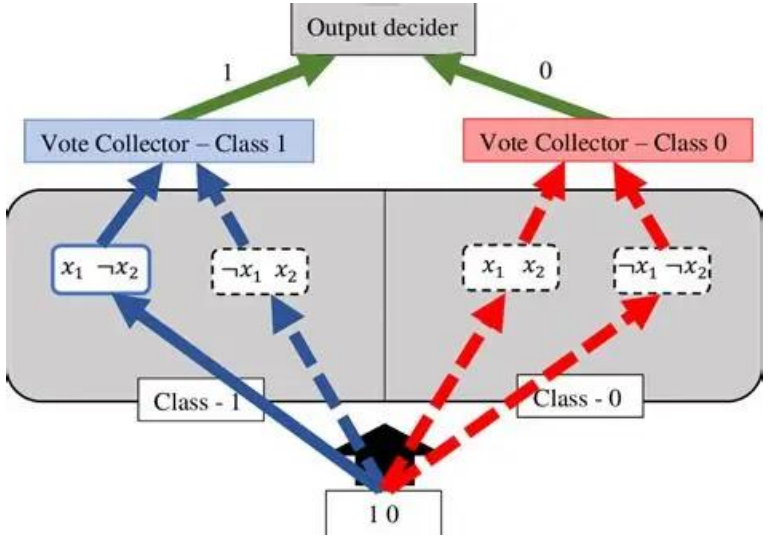
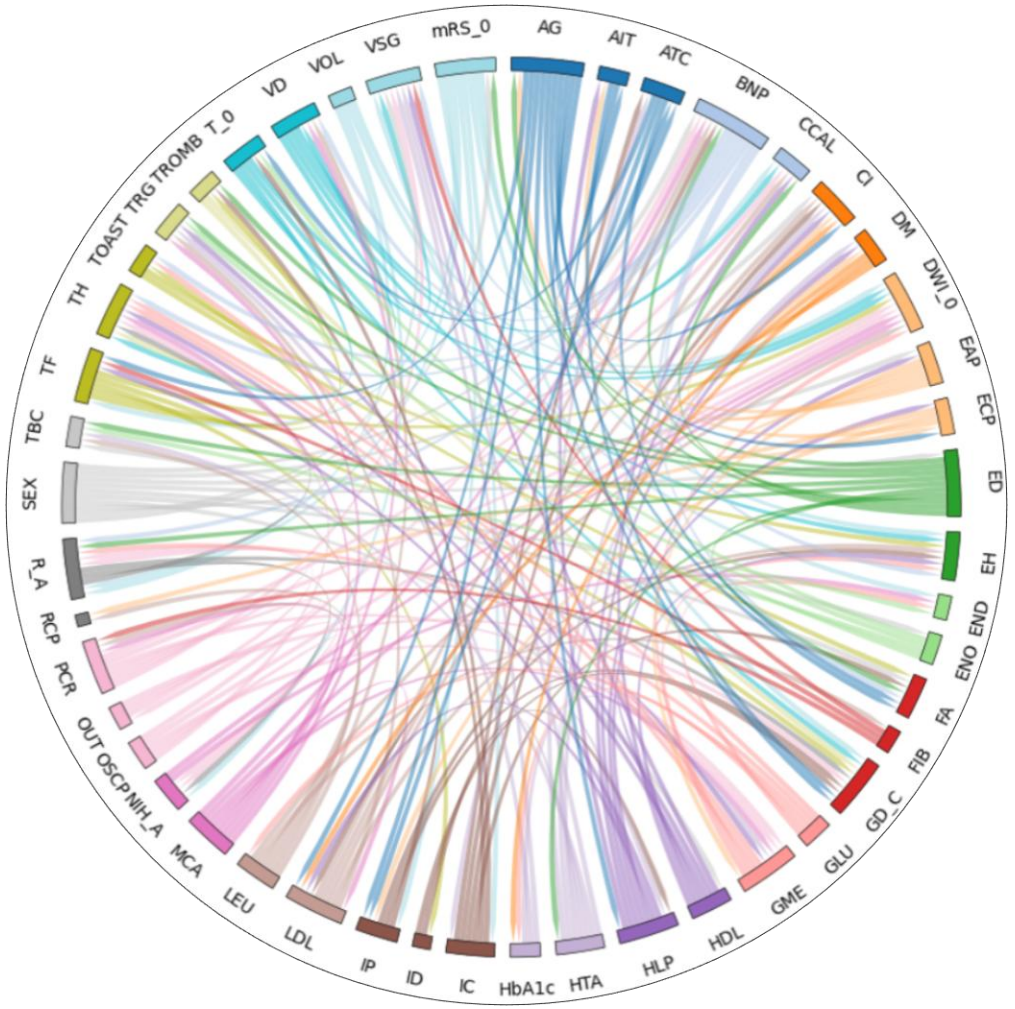


Image from 10.48550/arXiv.2005.05131 by Ole-Christoffer Granmo

Causal discovery,

1. Shows effects of each feature on others
2. Directional – identifying cause and effect
3. How to identify the most influential ones?

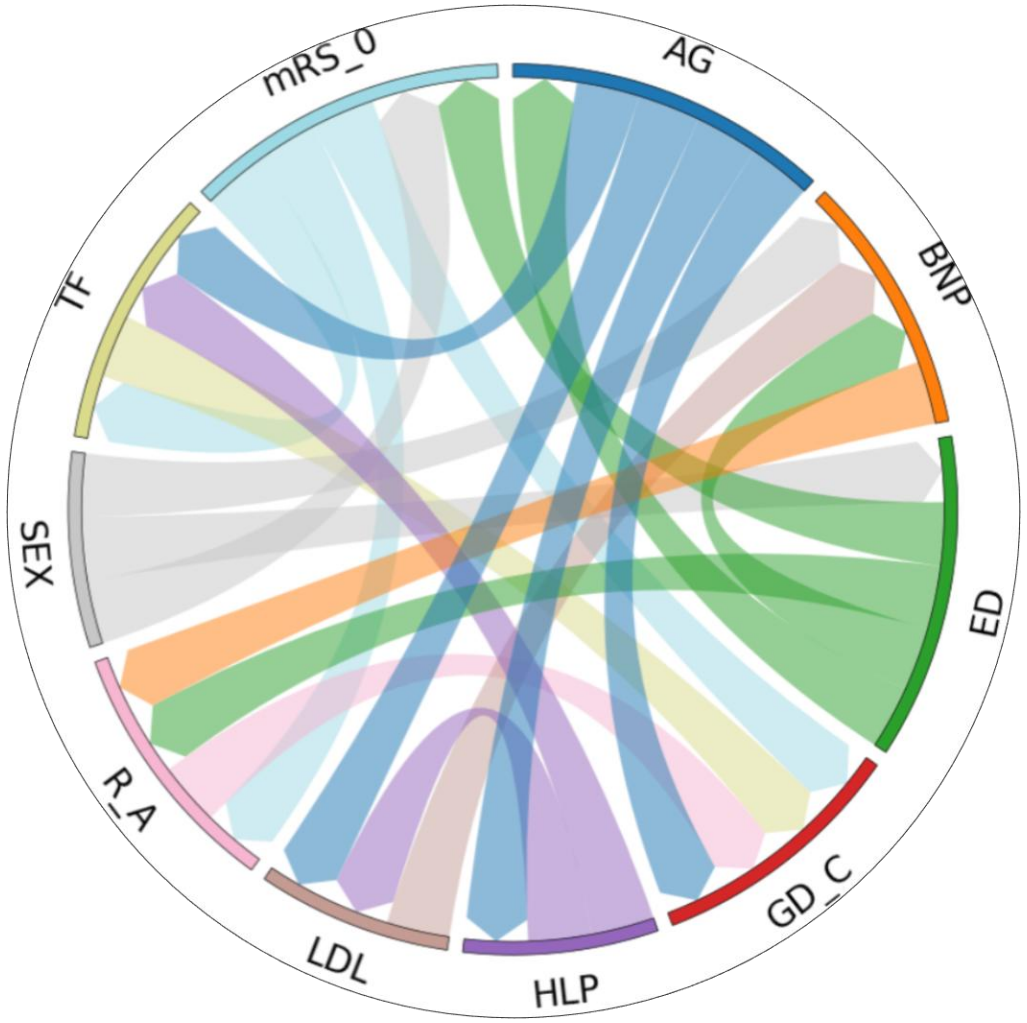


Ranking of features,

1. Degree Centrality:
   Number of direct connections
   Higher value → broad influence

2. Betweenness Centrality:
   A node's link to others
   Higher value → critical link

3. Compare with domain knowledge!



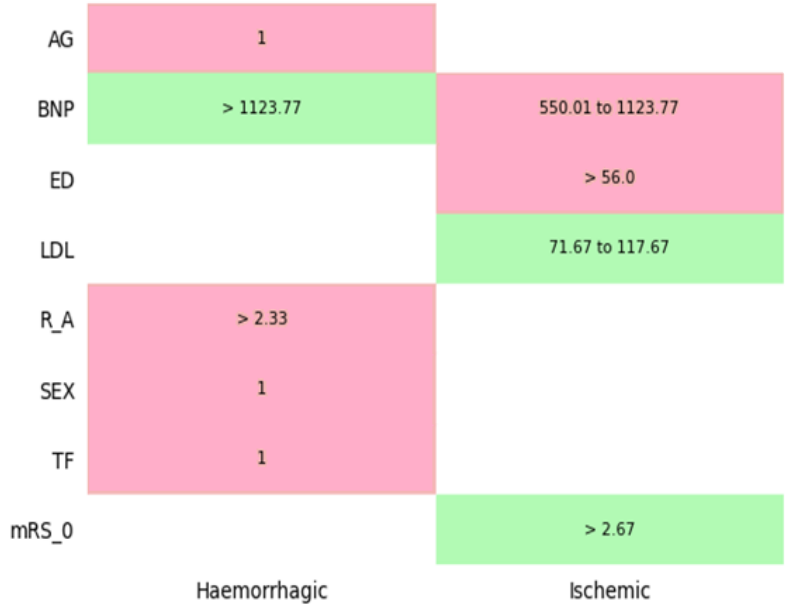
Results

Rules/clauses of Tsetlin Machine,

1. Binarization with bins for continuous variables

2. Voting weights for each generated clause

3. Helps identify,
   Most important features for a class
   Their value ranges



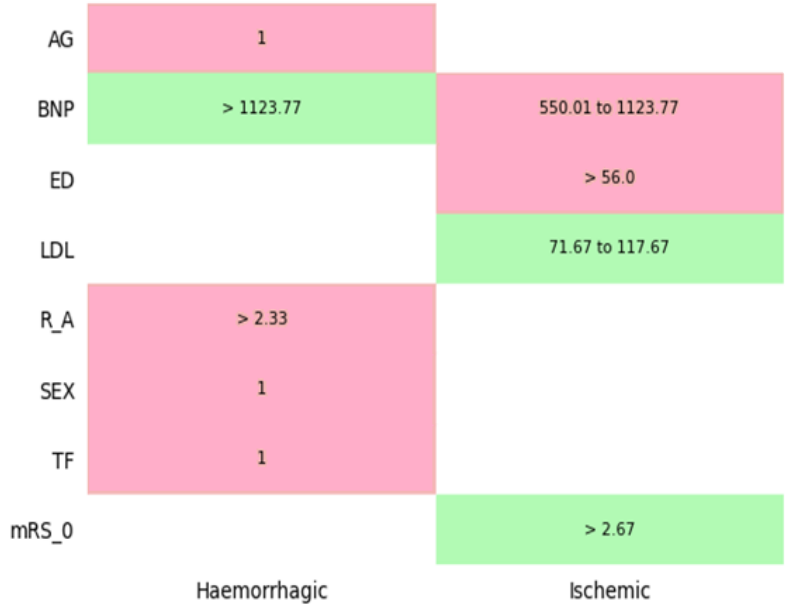
Results

Rules/clauses of Tsetlin Machine,

The clause for ischemic stroke would then be:

if mRS_0 > 2.67 and
LDL between 71 – 117 mg/dL and
Age NOT > 56 and
BNP NOT between 550 – 1123 pg/mL
then Ischemic.

Preliminary results - subject to further investigation*



- ✓ Remove bias in class distribution
- ✓ More robust model training
- ✓ More scenarios to run

More data

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More data

Improve causal inference

- ✓ Check for 'hidden' confounders
- ✓ Advanced algorithms for causal discovery
- ✓ Ensure the direction of causality with domain knowledge

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Improve causal inference

- ✓ Check for 'hidden' confounders
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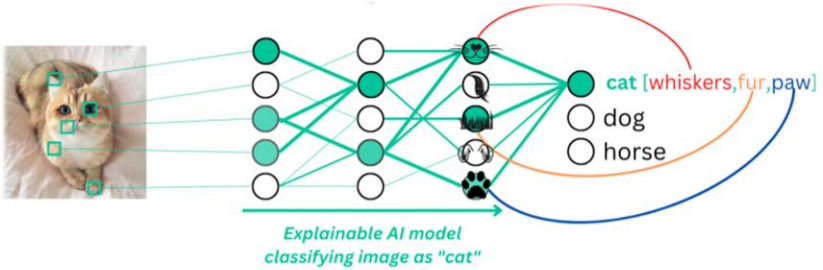
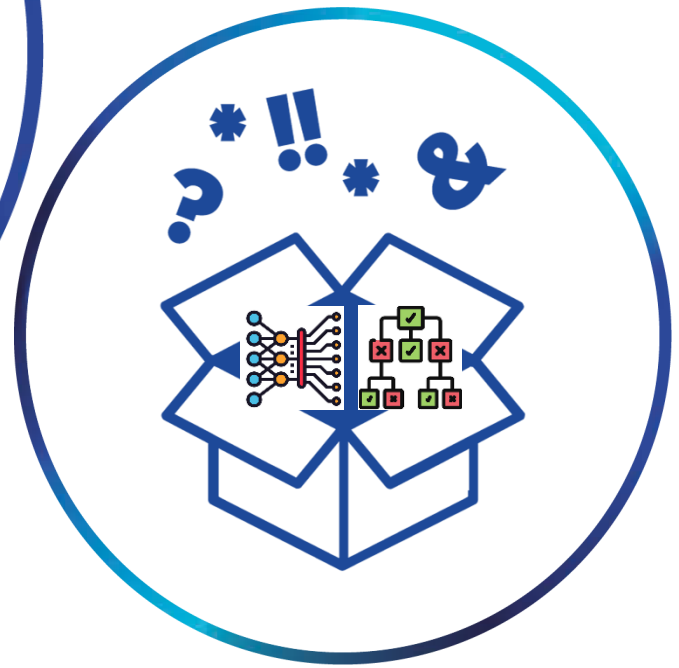
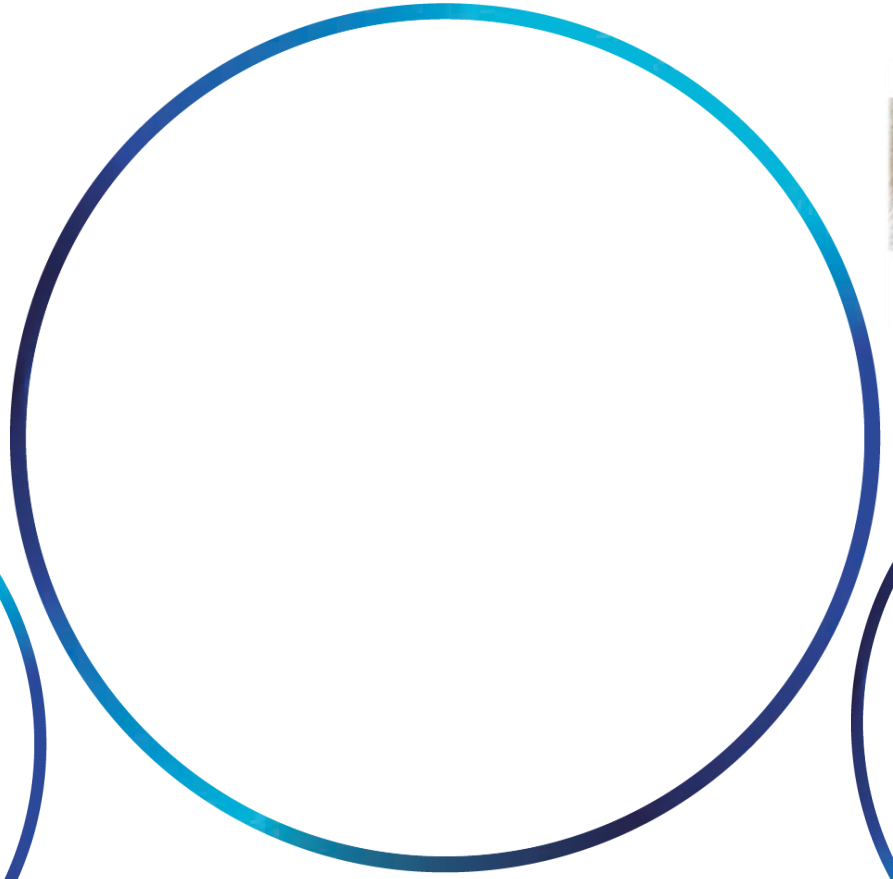
Fine tune TM clauses

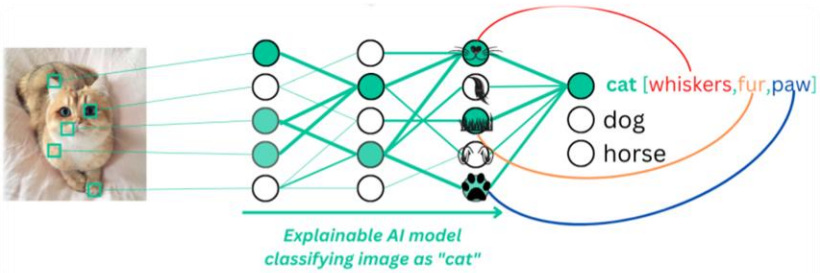
- ✓ Improve binarization with domain knowledge
- ✓ Resampling of data
- ✓ Clause weight distribution


cat [whiskers,fur,paw]
dog
horse
Explainable AI model
classifying image as "cat"




MEDICAL DATA

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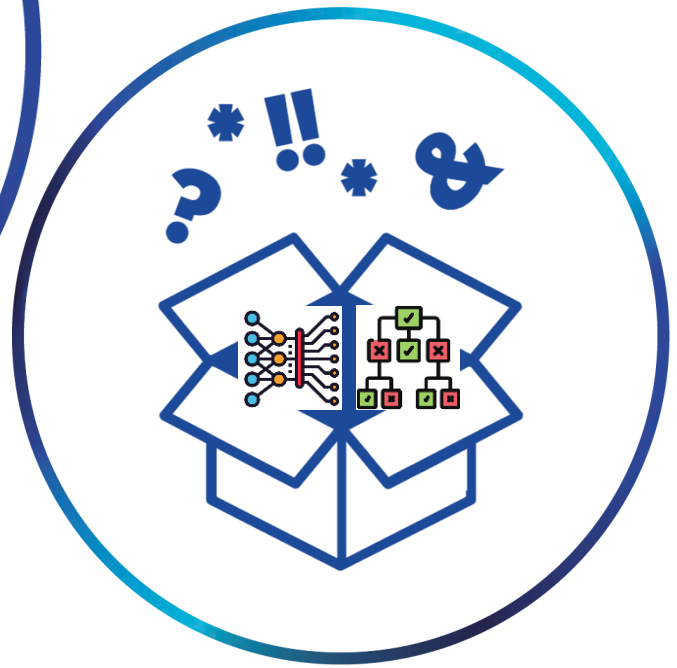
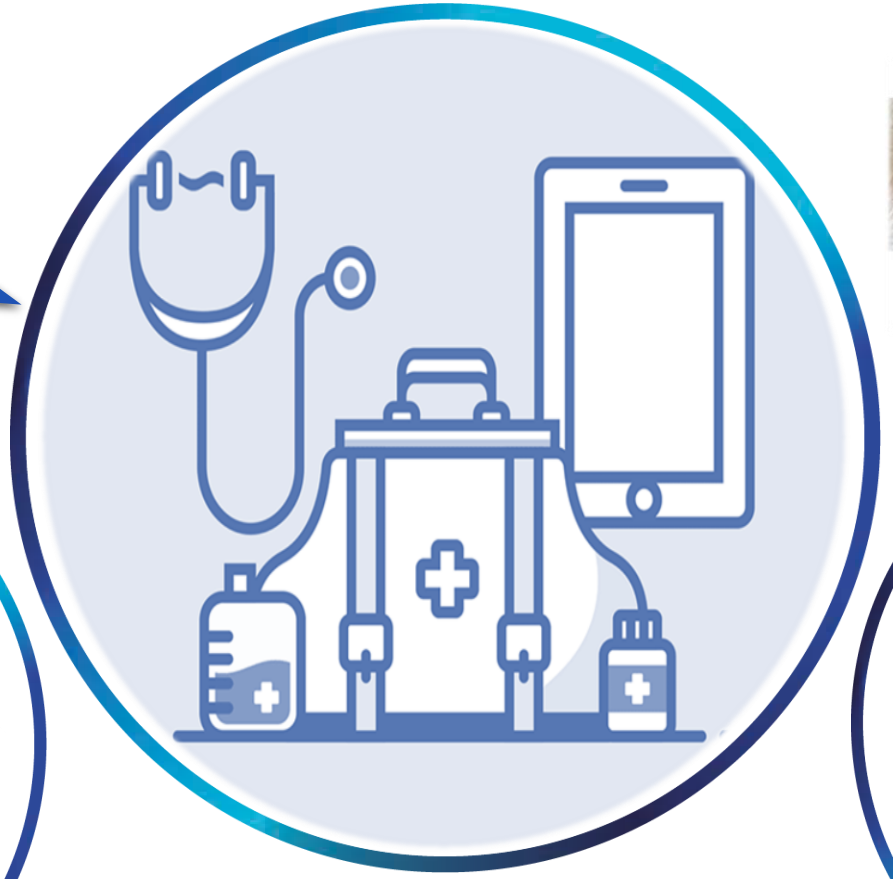
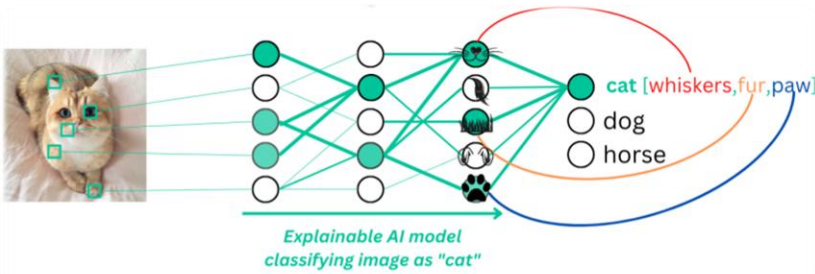
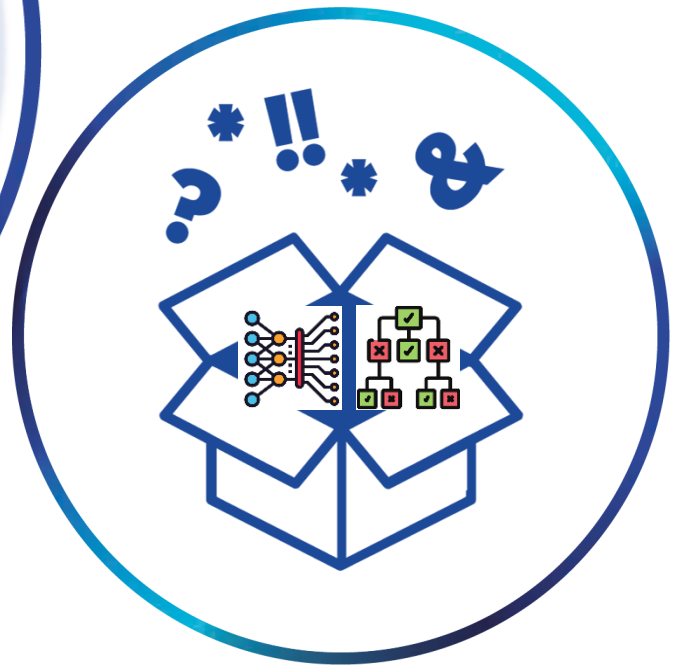
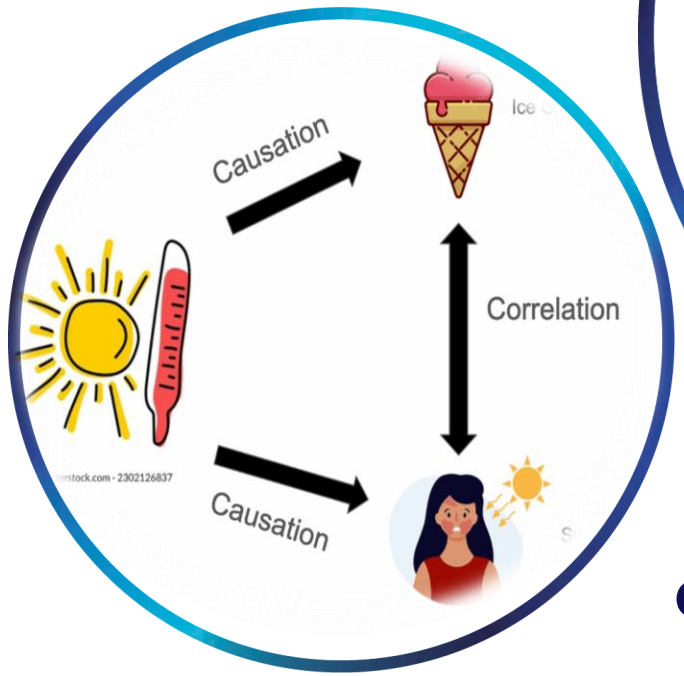


A product for medical professionals to help run *what if* scenarios…









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Capitole
A Decade of Innovation

Thank you!

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