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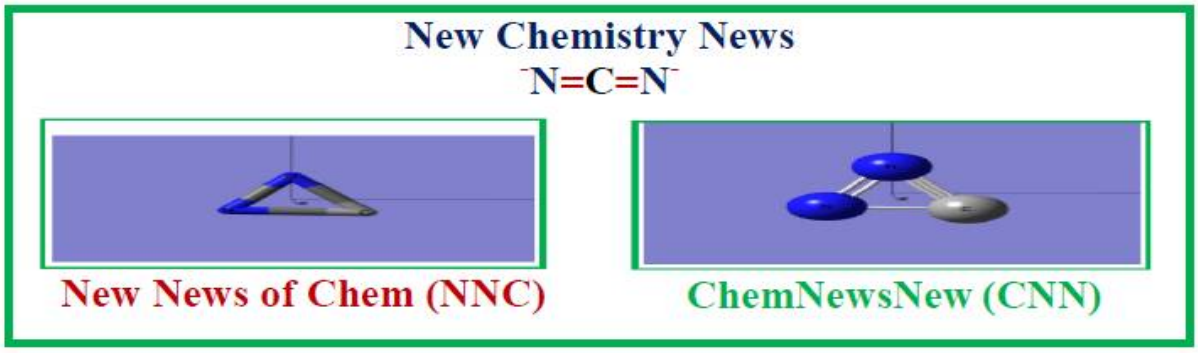


# CNN-54--Fit (Figure Image TableScript...)Bases (Bfit) Part 2.xAI.Medicine (xAIM)-2021



| Information Source | sciencedirect.com;ACS.org ; | |
|---|---|---|
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**Conspectus:** Data-,information-,knowledge-, intelligence-, method- bases play a pivotal role to understand, design and control desired targets in health, communication, defence and industrial domains. The evolution of data-acquisition methods of increasing accuracy/precision through electronic instruments revolutionised input to output transformation. In addition to numerical/logical/attribute data systems, 2D-/3D-images, figures, multi-way tables and scripts opened new vistas in data-to-information transformation in sub-goals of a task. In this decade, the application of adoptive-trust-worthy-nascent xAI tools in medical sciences changed the scenario of age-old practising protocols.In this communication, select research reports dealing with xAI in medical diagnosis during the year 2021 are briefly described

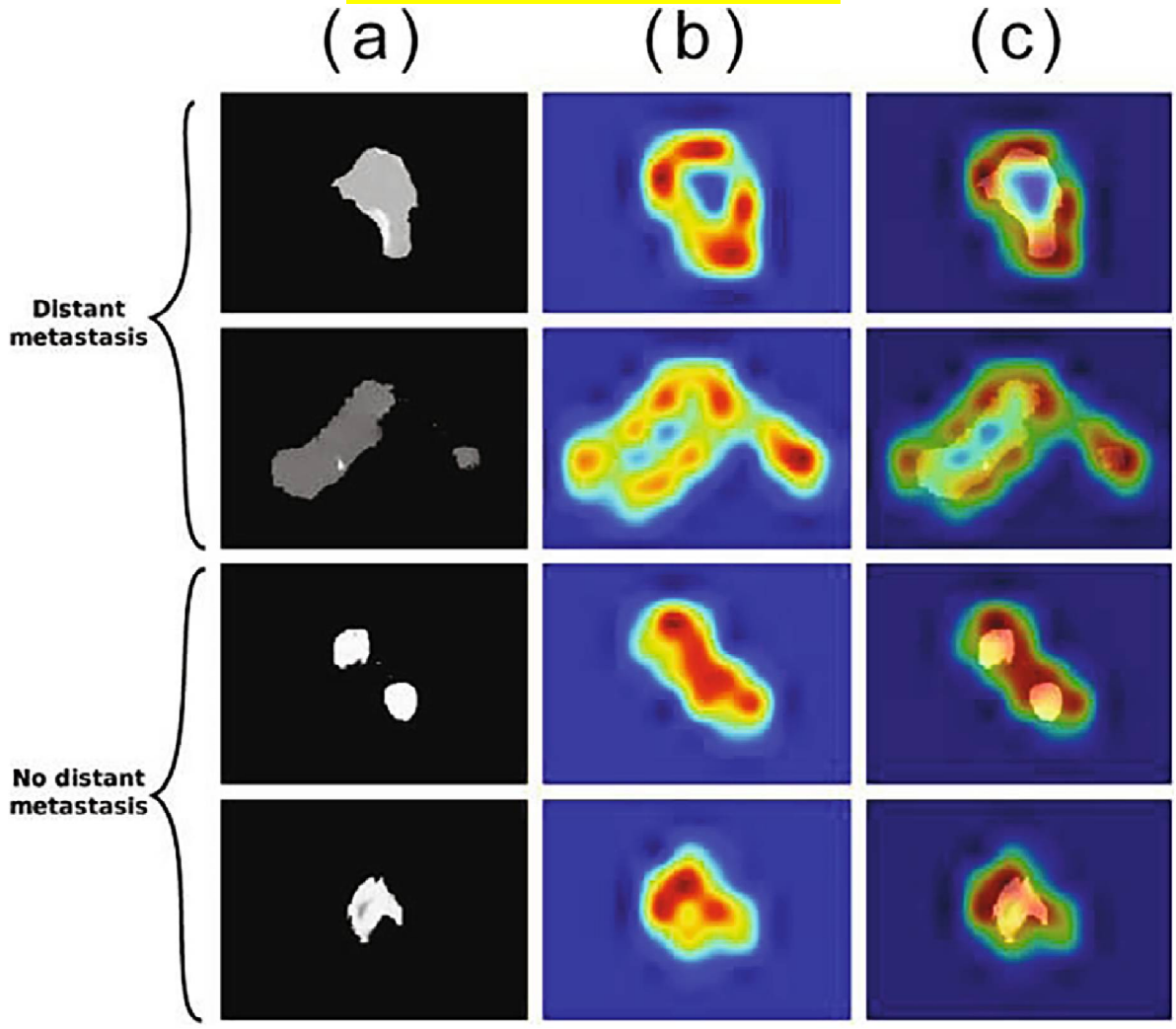
***Keywords*:** eXplainable/interpretable/Responsible/Trustworthy AI; Machine Learning; Deep architectures; Medical diagnosis; Cancer, Heart/brain/lung diseases; probes for xAI; Health care

| Layout | | |
|---|---|---|
| Diagnosis | Cancer | |
| | Heart diseases ECG Analysis | |
| | ASD | |
| | COVID-19 | |
| | | |
| Health | Drugs | |
| | Toxicology | |
| | Health-care | |
| | | |
| xAI | Framework- | K(nowledge)Lab |
| | Segmentation | rsr.chem1979 |
| | Explainability Interpretability | |
| | Pixel level | |
| xAI.Probes | Shapley-LIME | |
| | Heatmap | |
| | Saliency map | |
| | CAM Grad CAM | |
| | tSNE | |
| | Variable Imp plot | |
| | Variable Imp plot | |

# Cancer

| xAI.Med. | | 2021-09 |
|---|---|---|

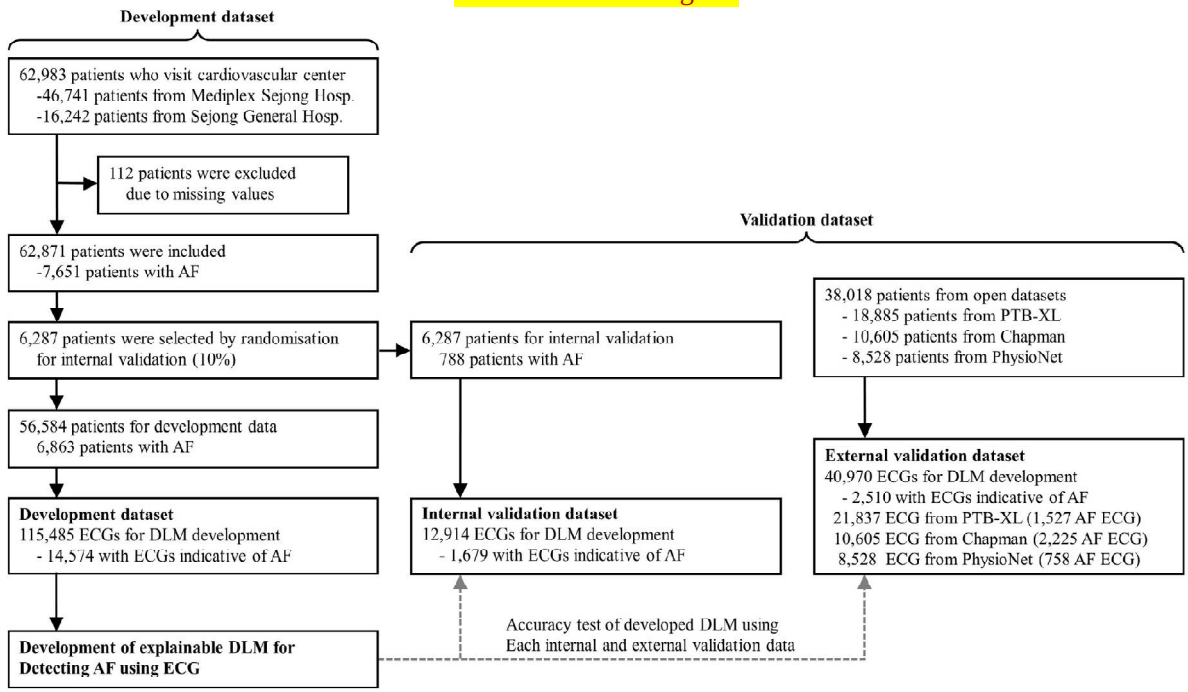
Distant metastasis in head and Neck Cancer




a) Raw images imported to the model
b) Gradient class activation map (Grad-CAM) of the penultimate convolution block
c) Merged image of columns a, and b

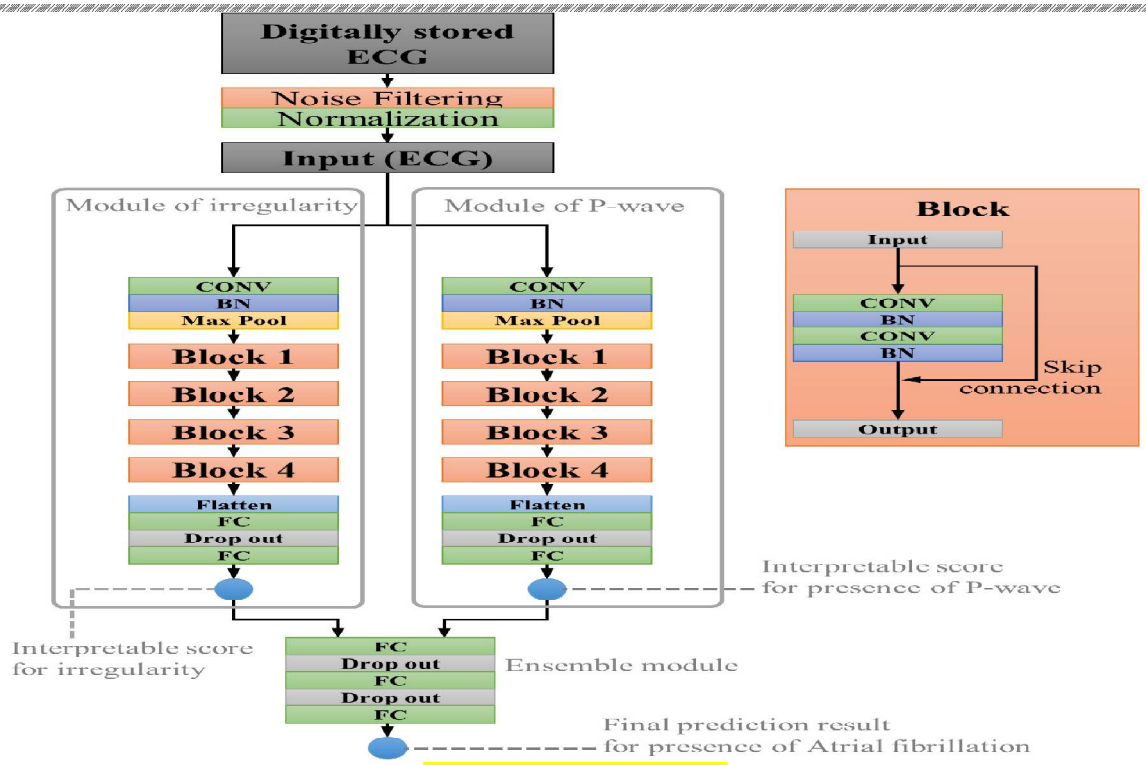
# Heart diseases

DataSet – Flow Diagram




xAI.Med. 2021-31

Explainable DLM for detecting atrial fibrillation

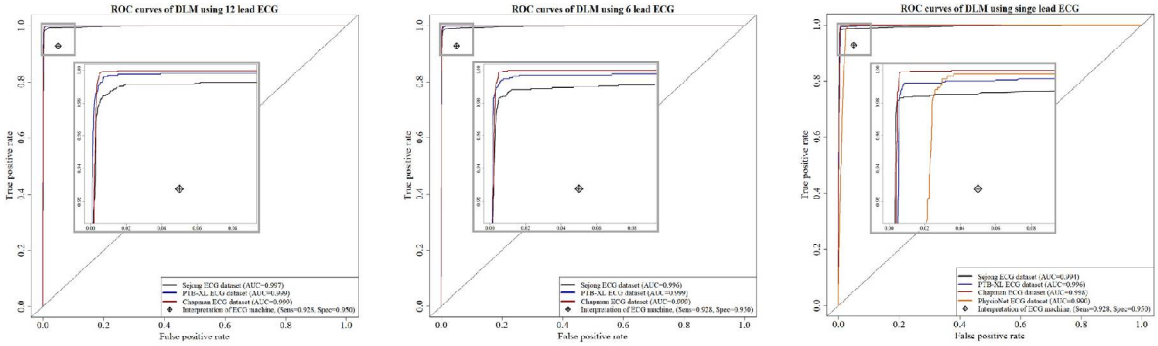



DLM deep learning model

| | |
|---|---|
| BN denotes batch normalization layer<br>CONV convolutional neural network layer<br>FC fully connected layer | ECG electrocardiogram |

| xAI.Med. | | 2021-31 |
|---|---|---|

Performances of explainable deep learning model to detect atrial fibrillation

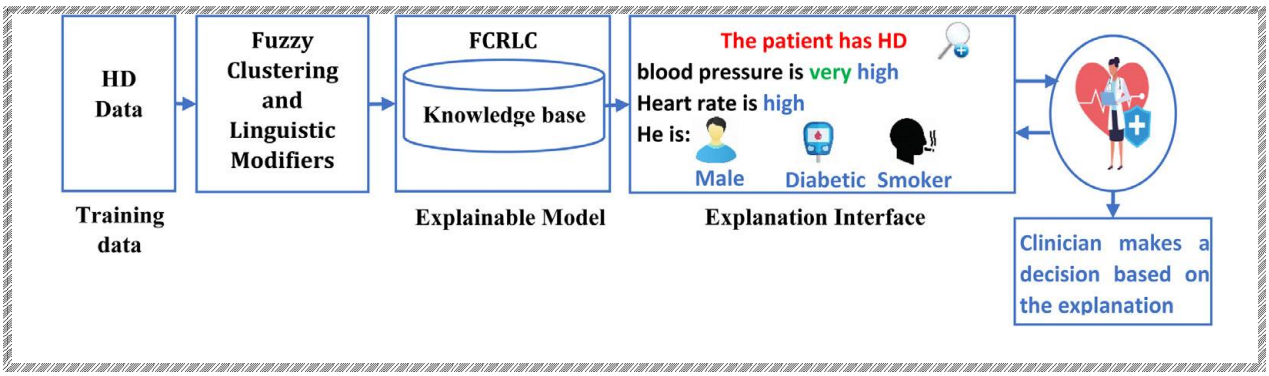



ECG electrocardiogram-- DLMdeeplearningmodel

| | |
|---|---|
| o CI confidence interval | o NPV negative predictive value<br>o PPV positive predictive value |

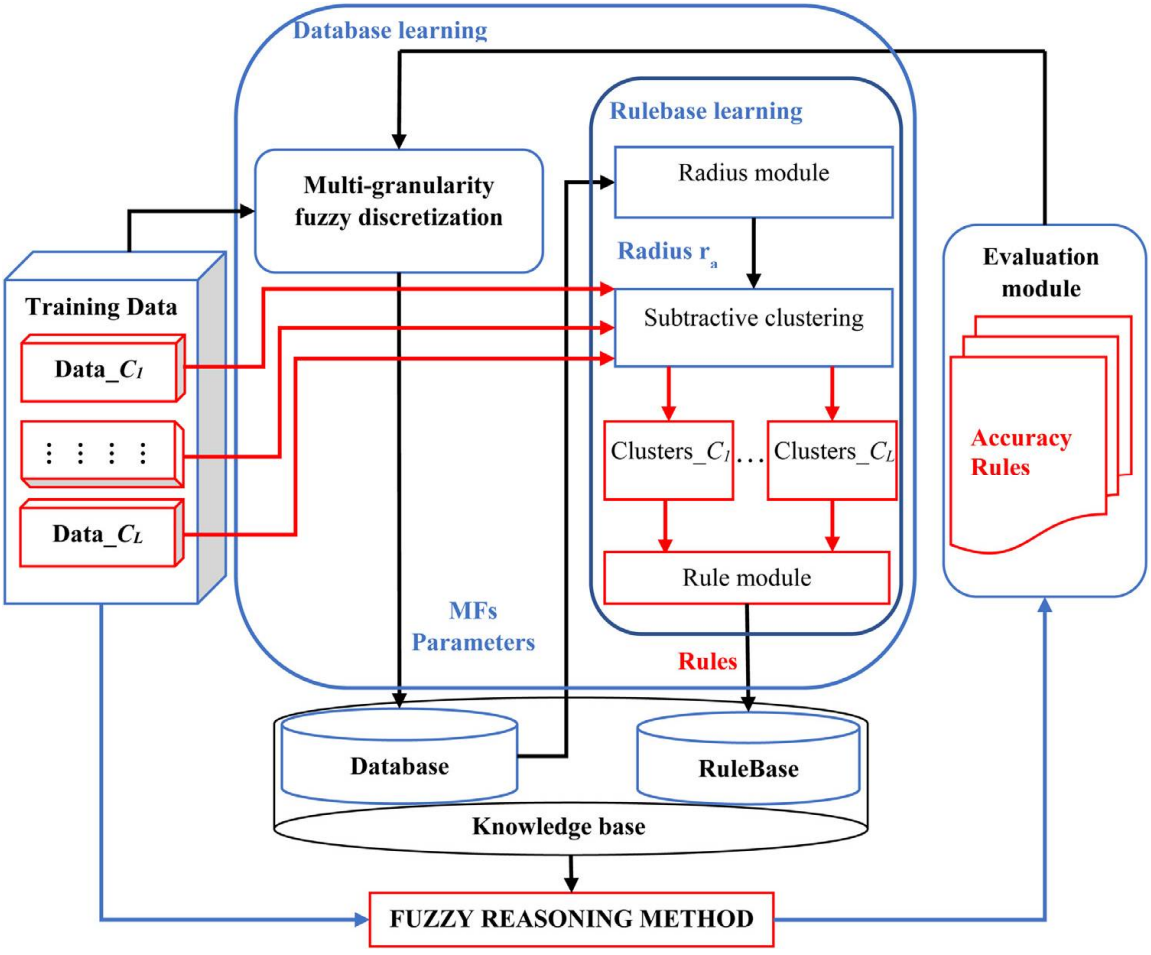
| xAI.Med. | Heart | 2021-20 |
|---|---|---|

Explainable prediction model of heart disease





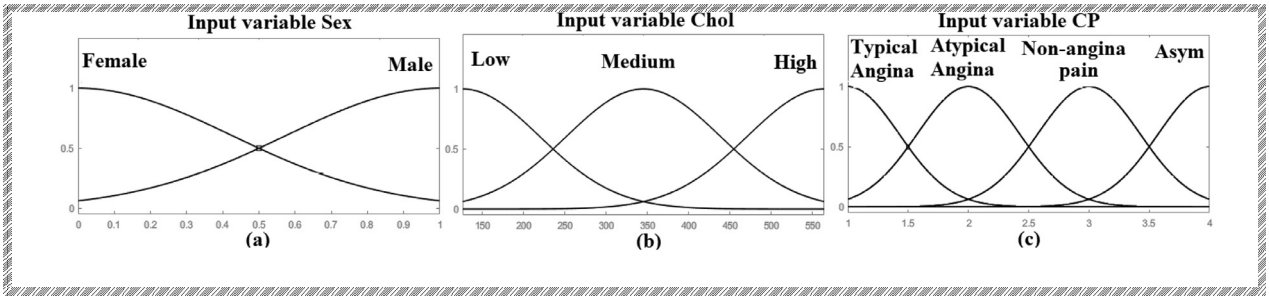

FCRLC architecture





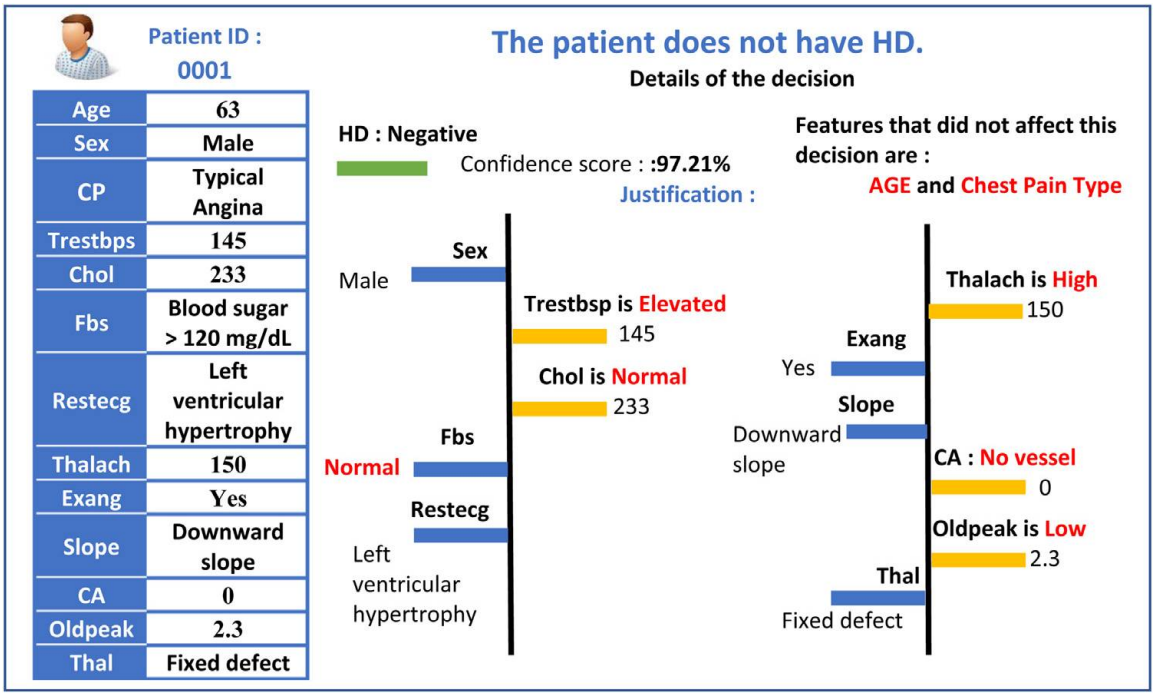

Fuzzy partitions of linguistic variables

Sex , Chol; CP





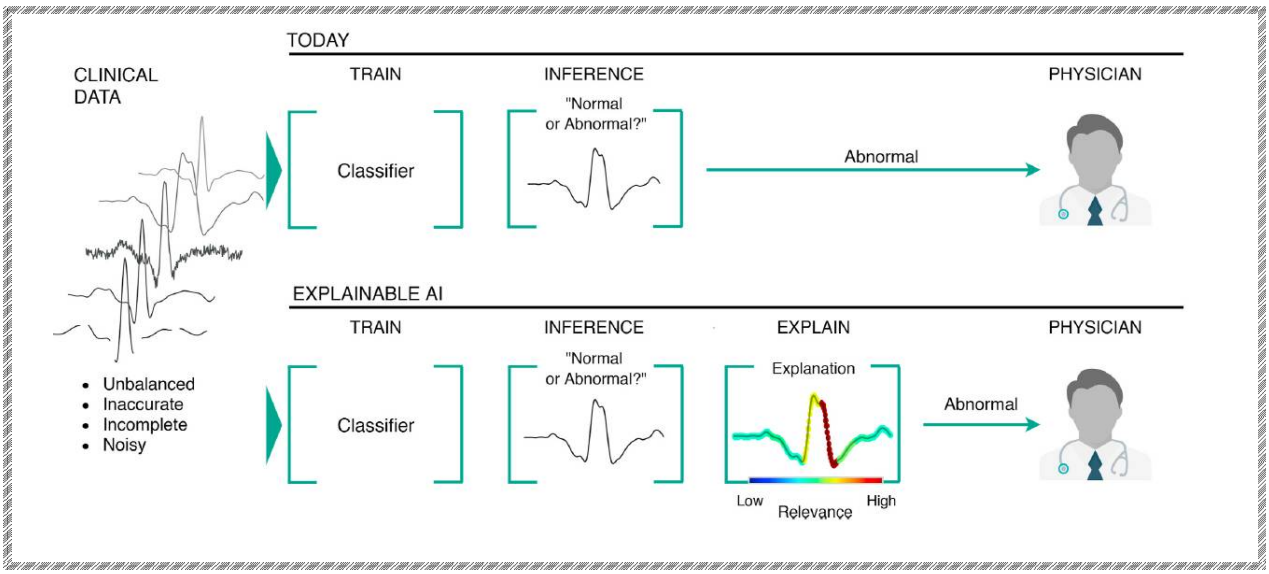

Explanation interface of FCRLC



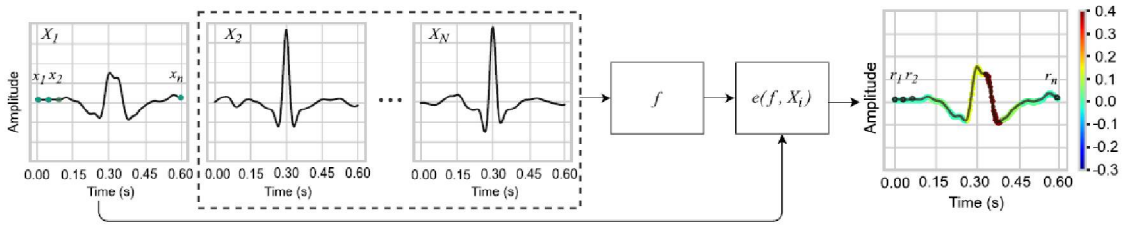

# ECG Analysis



Mach Lrn and xAI



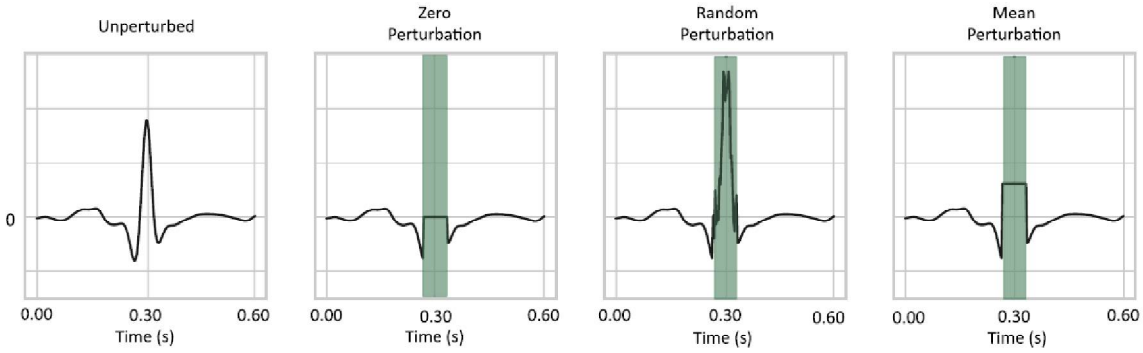

**xAI.Med.** 2021-06




Incorporating explanation in time series

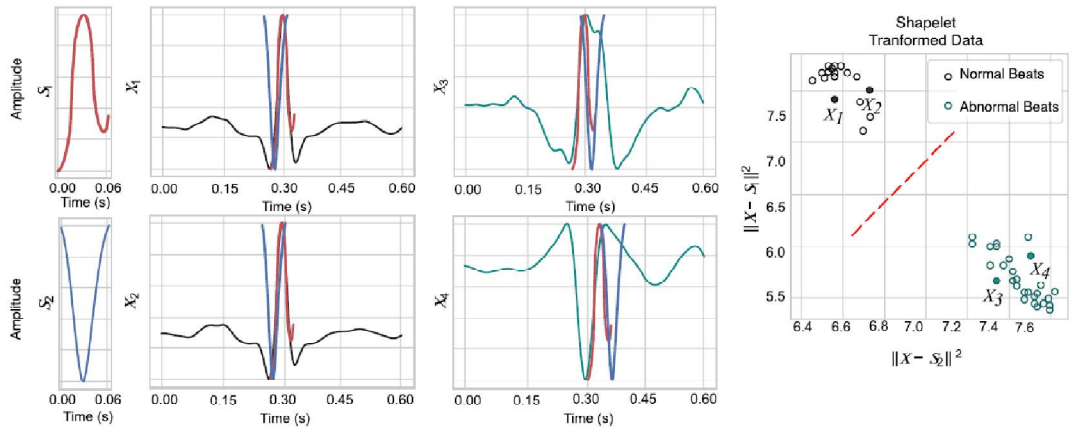
**xAI.Med.** 2021-06

possible perturbations applied to the R peak of the heartbeat



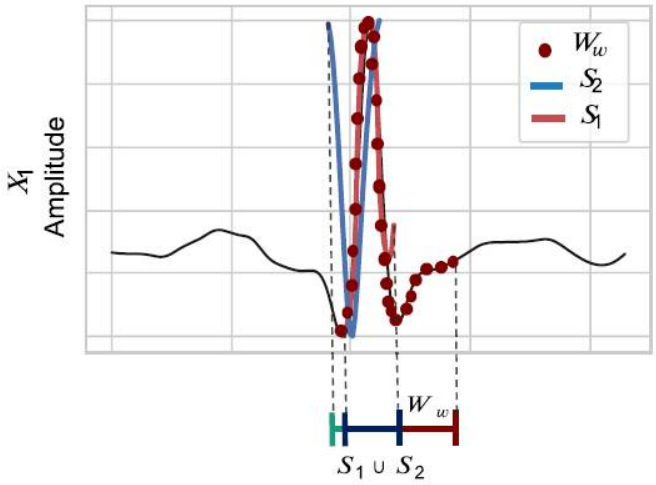

**xAI.Med.** 2021-06

shapelets S1, S2--- MIT-BIH ECG dataset





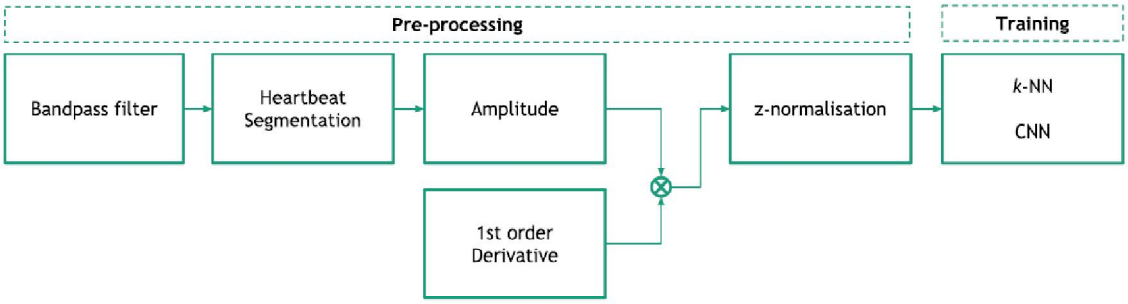

## Jaccard's index



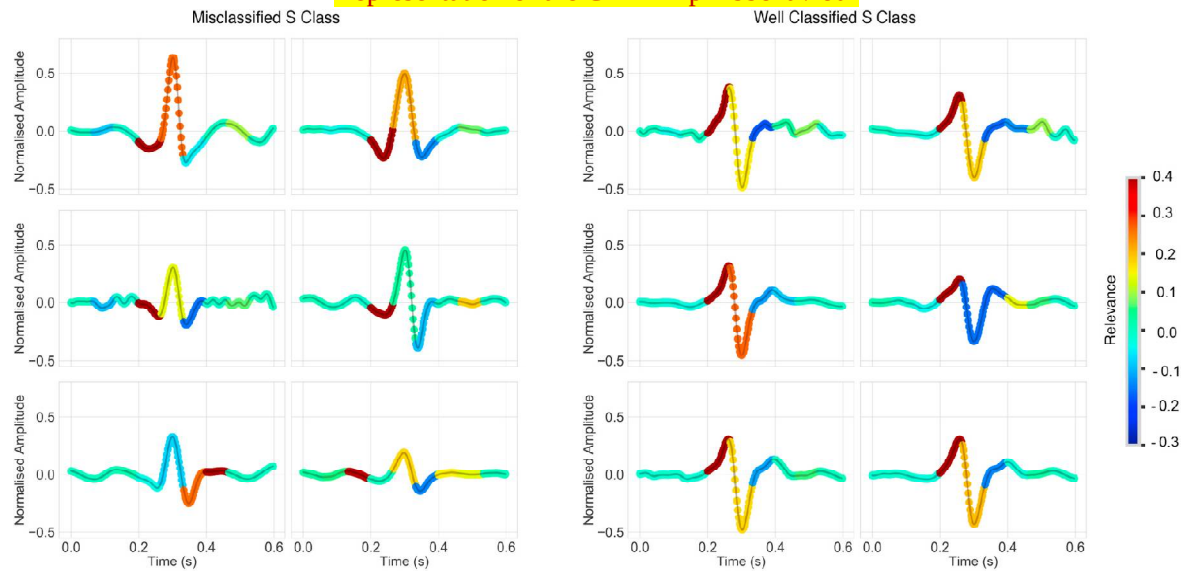

$$J(Shapelets, W_w) = \frac{\text{intersection}}{\text{union}}$$



## Post-hoc methods



Representation of the CNNAmpmisbehaviour

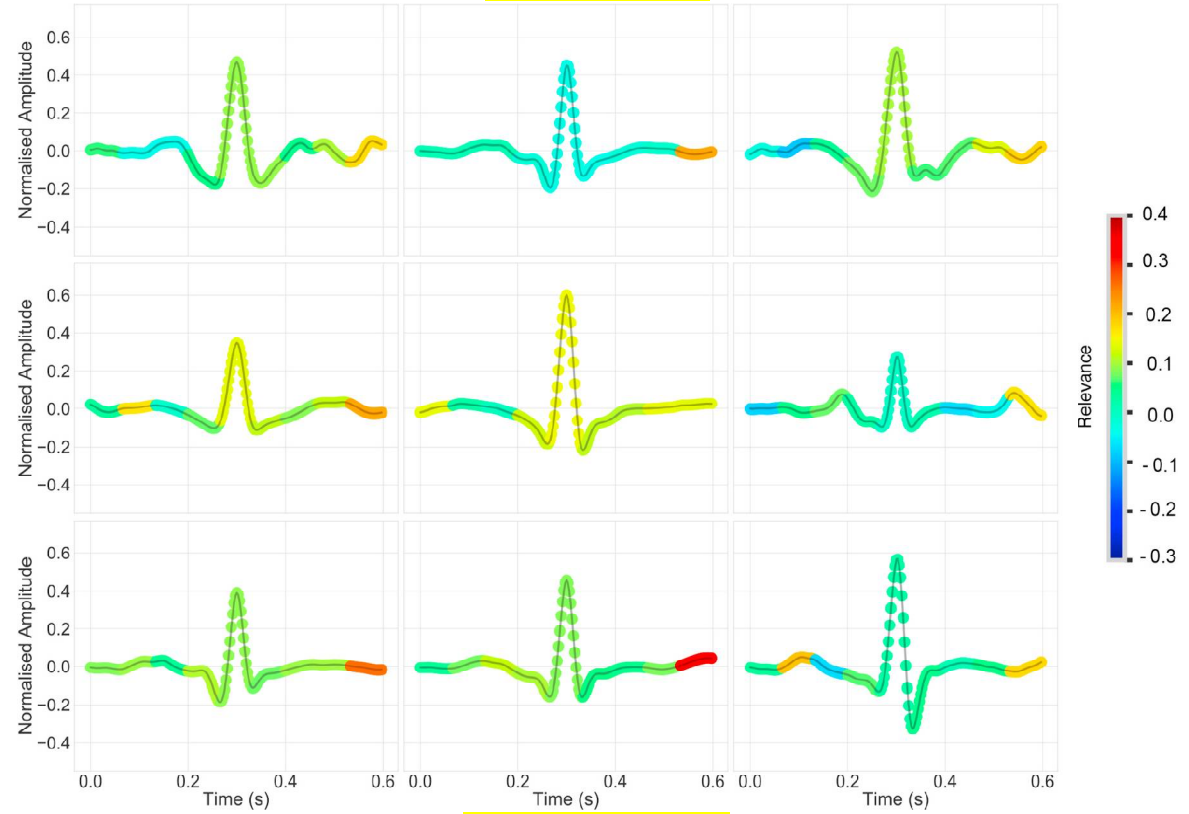



LIME explanations for false negatives of class S (on the left)

LIME explanations for correct classifications of class S (on the right)



SHAP explanations



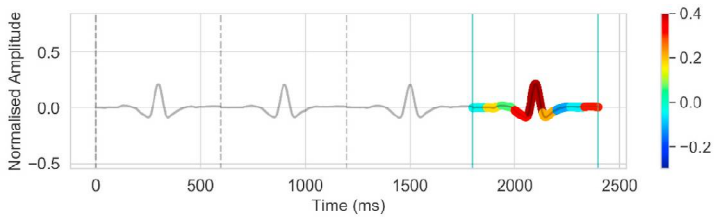

Binary CNNAmp+Dev


A screenshot of visual explanation for a single ECG

xAI.Med. 2021-06

visual explanation for a single ECG

For the case above, the machine gives the following visual aid.




With this kind of "explanation" would you change your mind?

Choose one of the following answers

- (●) No, I confirm
- ( ) yes, now I see it's non-ectopic
- ( ) yes, now I see it's supraventricular ectopic
- ( ) yes, now I see it's ventricular ectopic
- ( ) yes, now I see it's fusion beat
- ( ) I still really don't know

NB: ***look at the color scale on the right; you can disregard the numerical value therein indicated, but the higher this latter value is (and the more "red" the color), the more relevant the highlighted portion of the heartbeat is in regard to the right classification of the heartbeat itself.***

The heartbeat should be classified as **Non-Ectopic Heartbeat**.

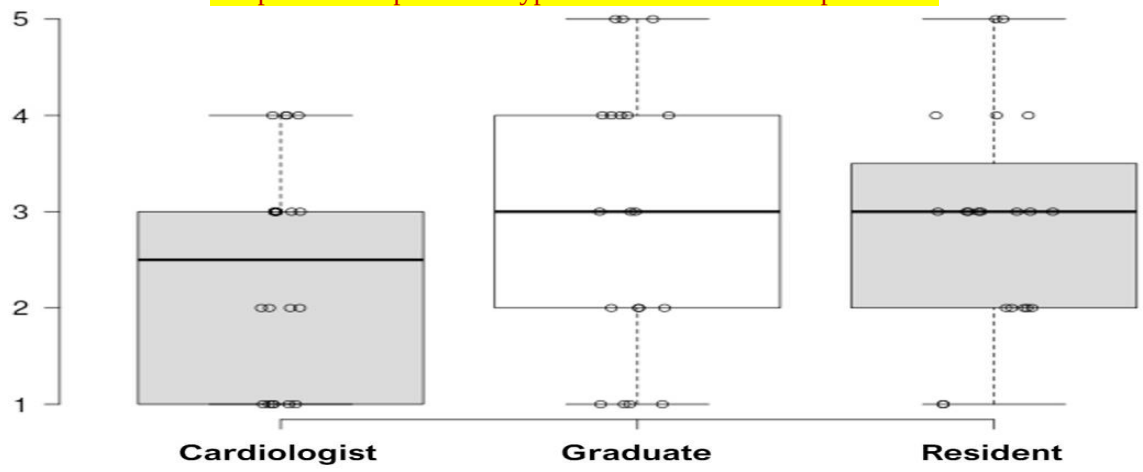
Assuming this classification correct, how useful do you consider the visual aid given above to reach an accurate classification?

Choose one of the following answers

- ( ) Very helpful (molto utile)
- ( ) Quite helpful (abbastanza utile)
- ( ) Neither helpful nor unhelpful (né utile, né inutile)
- ( ) Quite useless (abbastanza inutile)
- ( ) Totally useless (assolutamente inutile)
- ( ) Not only unhelpful, but even misleading! (Non solo inutile, addirittura fuorviante!)

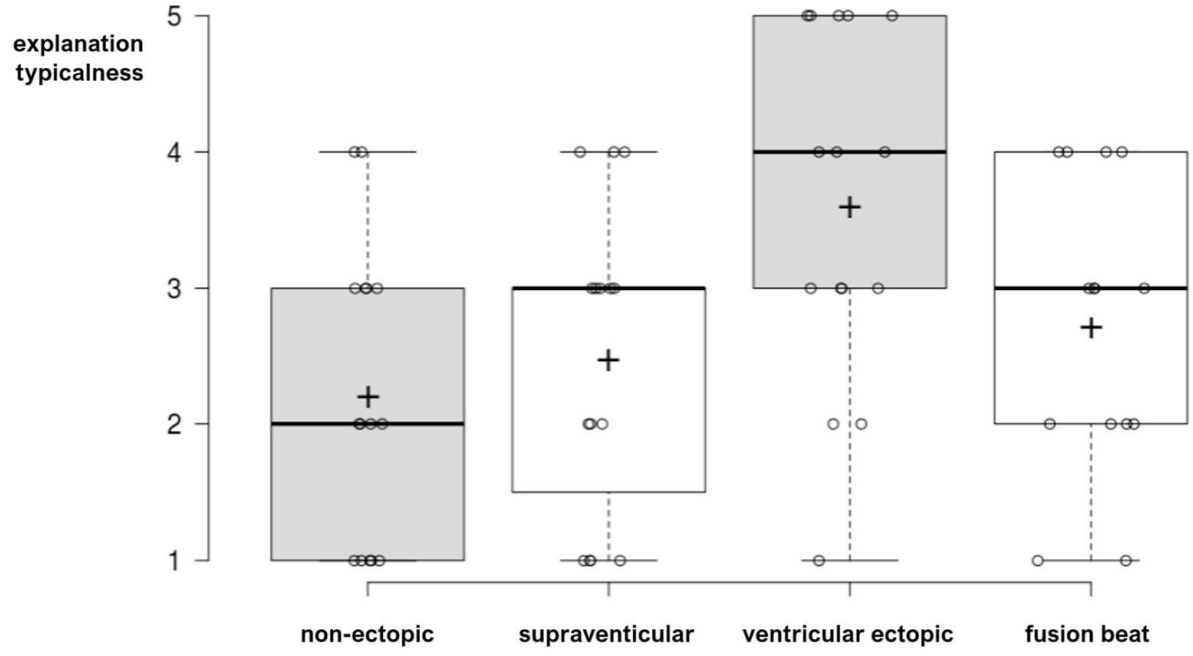


Boxplots of the perceived typicalness of the visual explanations



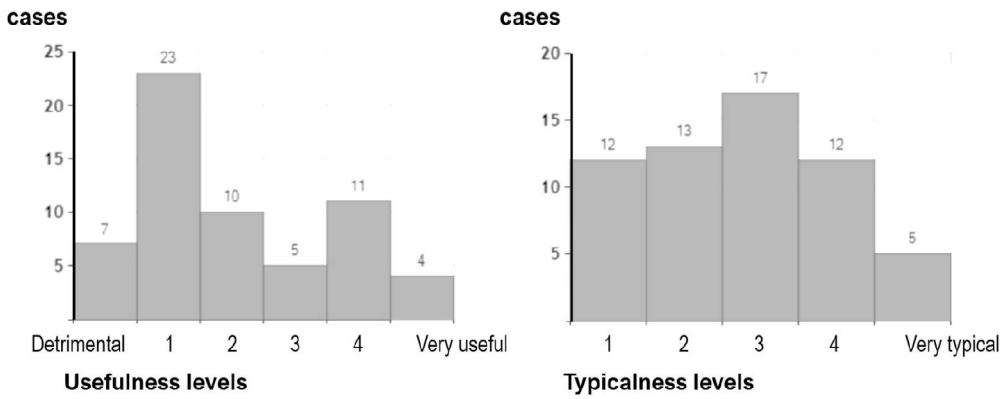
| xAI.Med. | 2021-06 |
|---|---|

Boxplots of the visual explanations --- grouped by kind of heartbeat




- ✓ Circles correspond to the explanations of the single ECGs
- ✓ Averages are indicated with a small cross

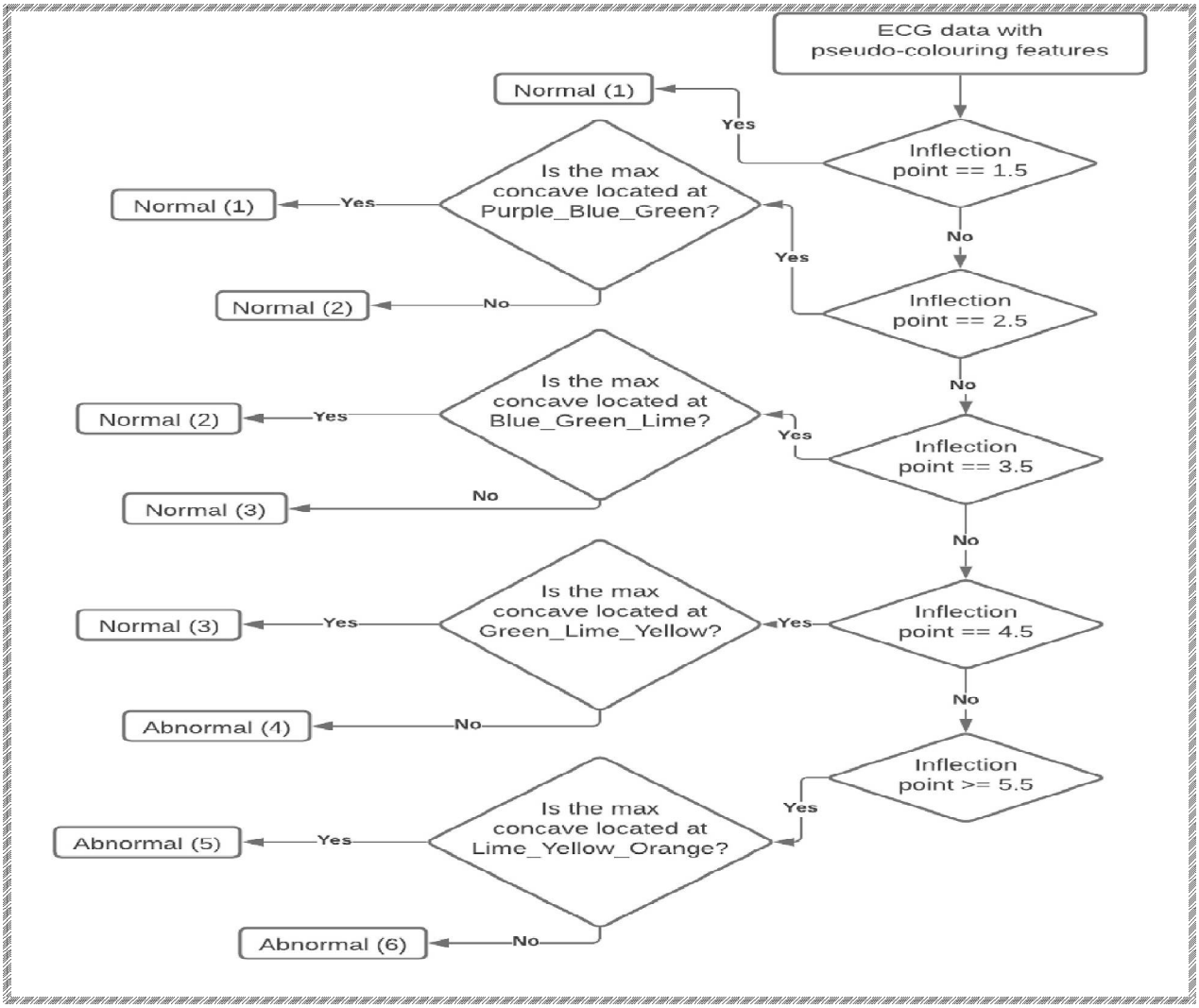
| xAI.Med. | 2021-06 |
|---|---|




Histograms of the perceived usefulness and typicalness of the explanations

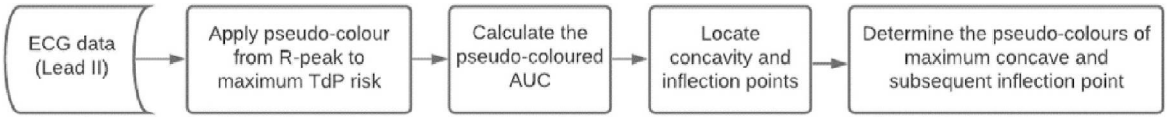
| xAI.Med. | 2021-112 |
|---|---|

Expert IF-THEN rules



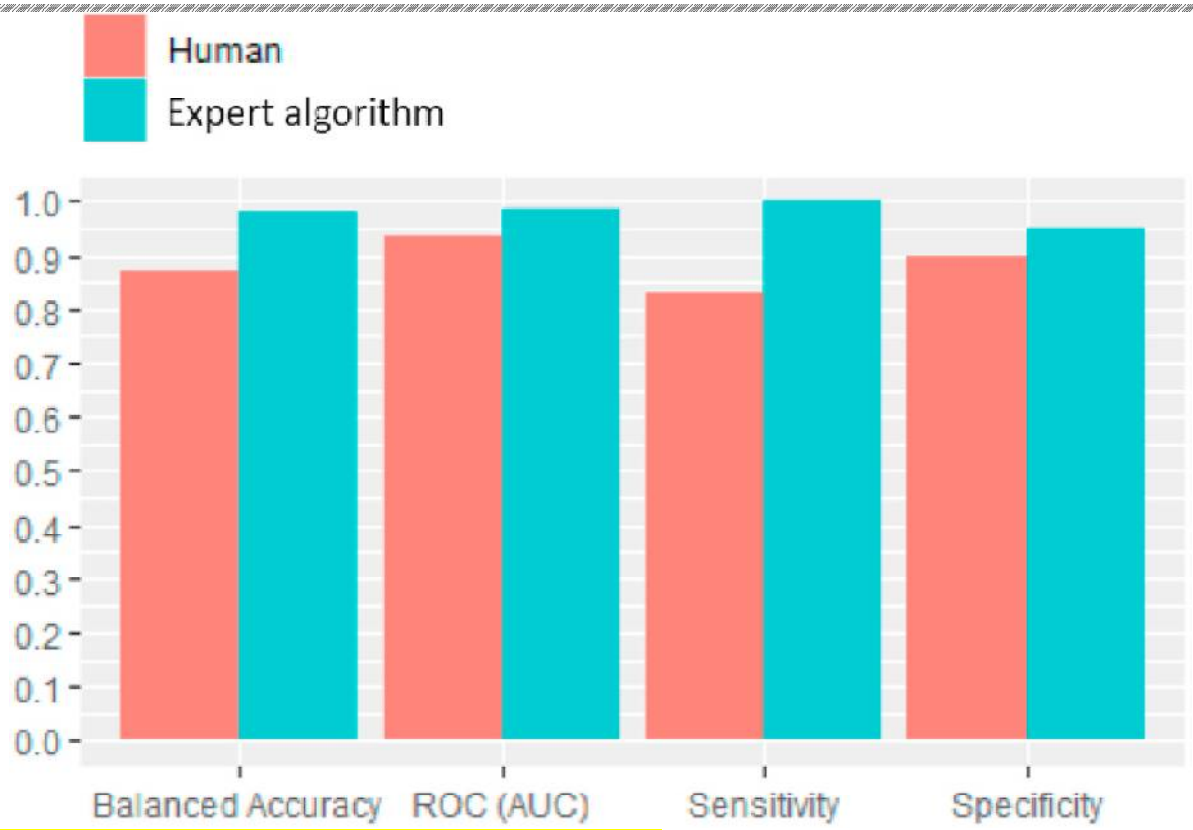

| xAI.Med. | | 2021-112 |
|---|---|---|

Expert algorithm's inference process




| xAI.Med. | | 2021-112 |
|---|---|---|

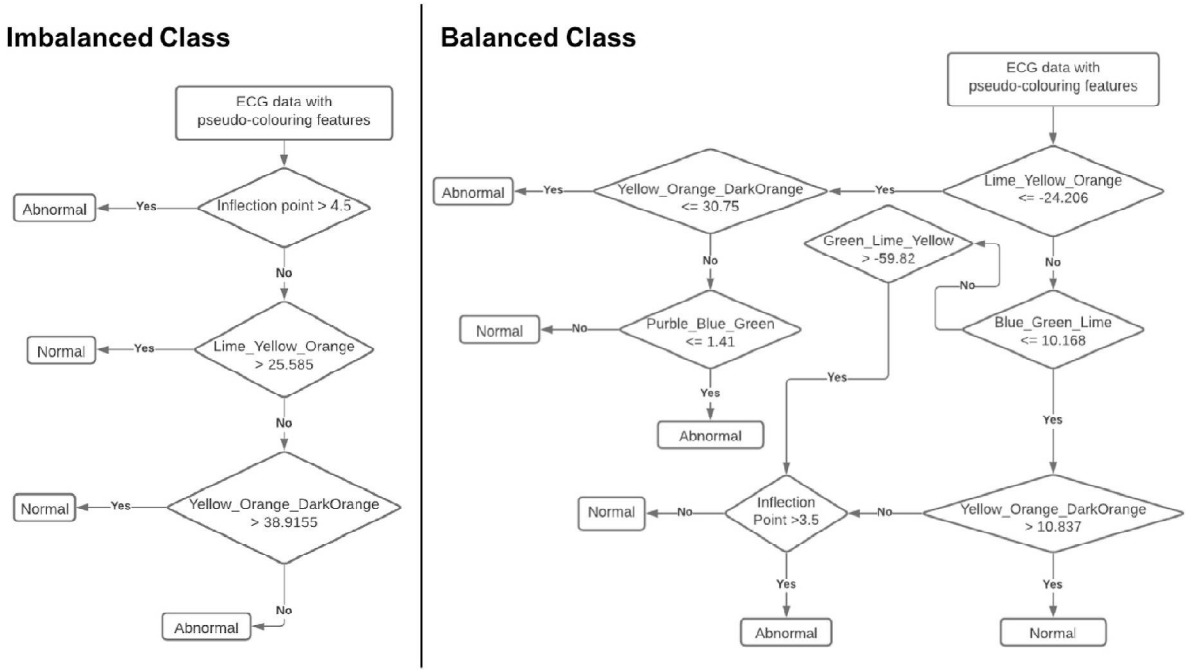
sensitivity, specificity, balanced accuracy, and area under the ROCcurve of the expert algorithm and human participants (mean values)




Classification: 40 ECGs (TdP risk n = 20, no risk n = 20)

**xAI.Med.** | 2021-112

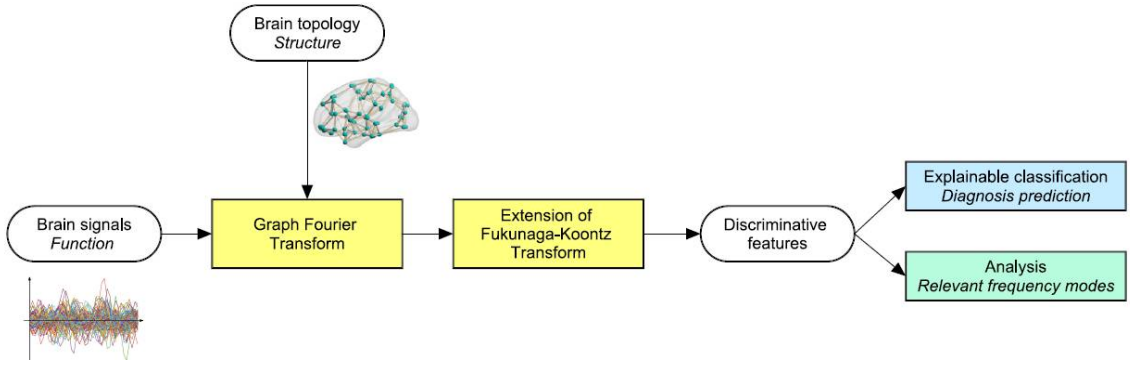
Decision tree IF-THEN rules when trained on imbalanced and balanced class data



# ASD

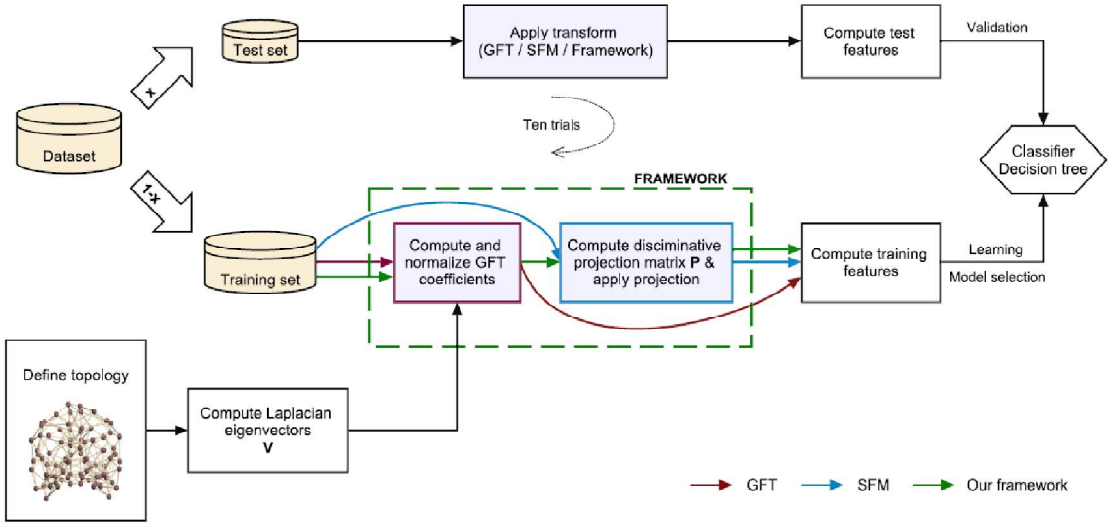
xAI.Med. 2021-05

Method-flow

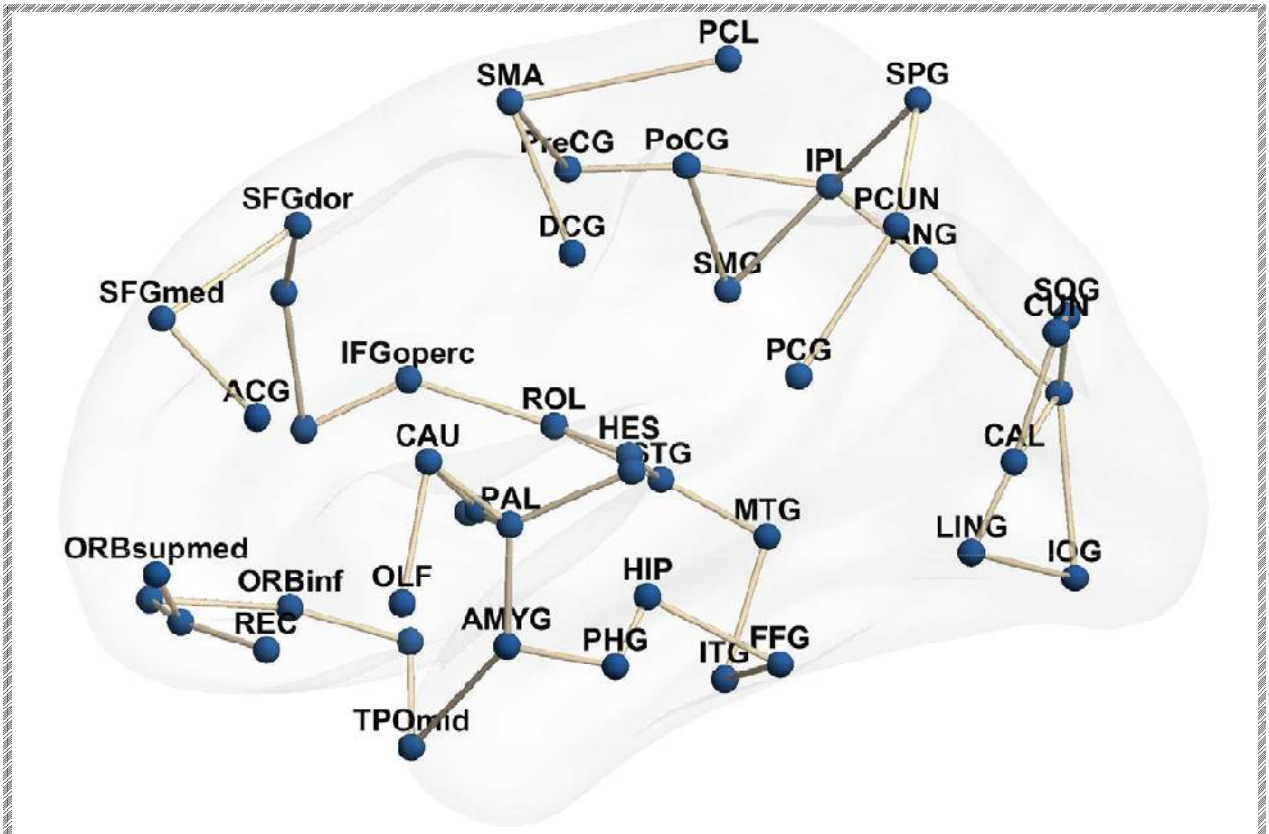



xAI.Med. 2021-05

Method-flow



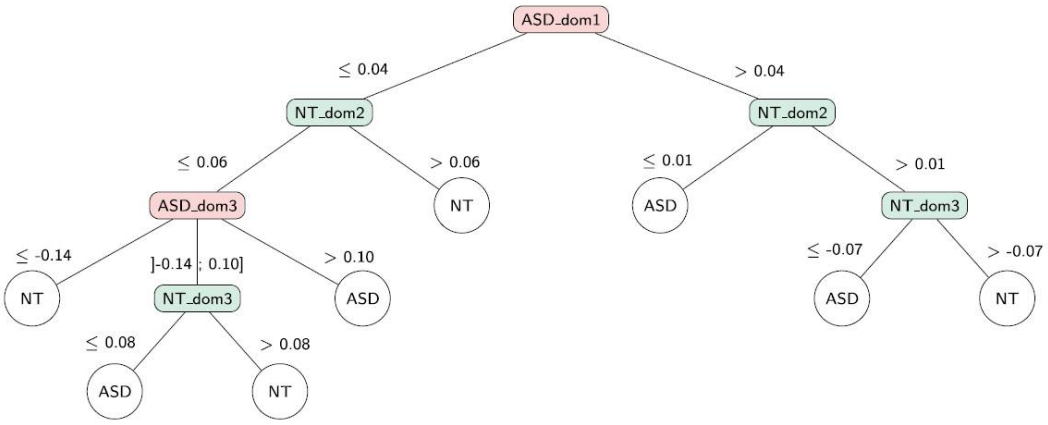

xAI.Med. 2021-05




Two-nearest neighbor topology in the right hemisphere

| xAI.Med. | | 2021-05 |
|---|---|---|

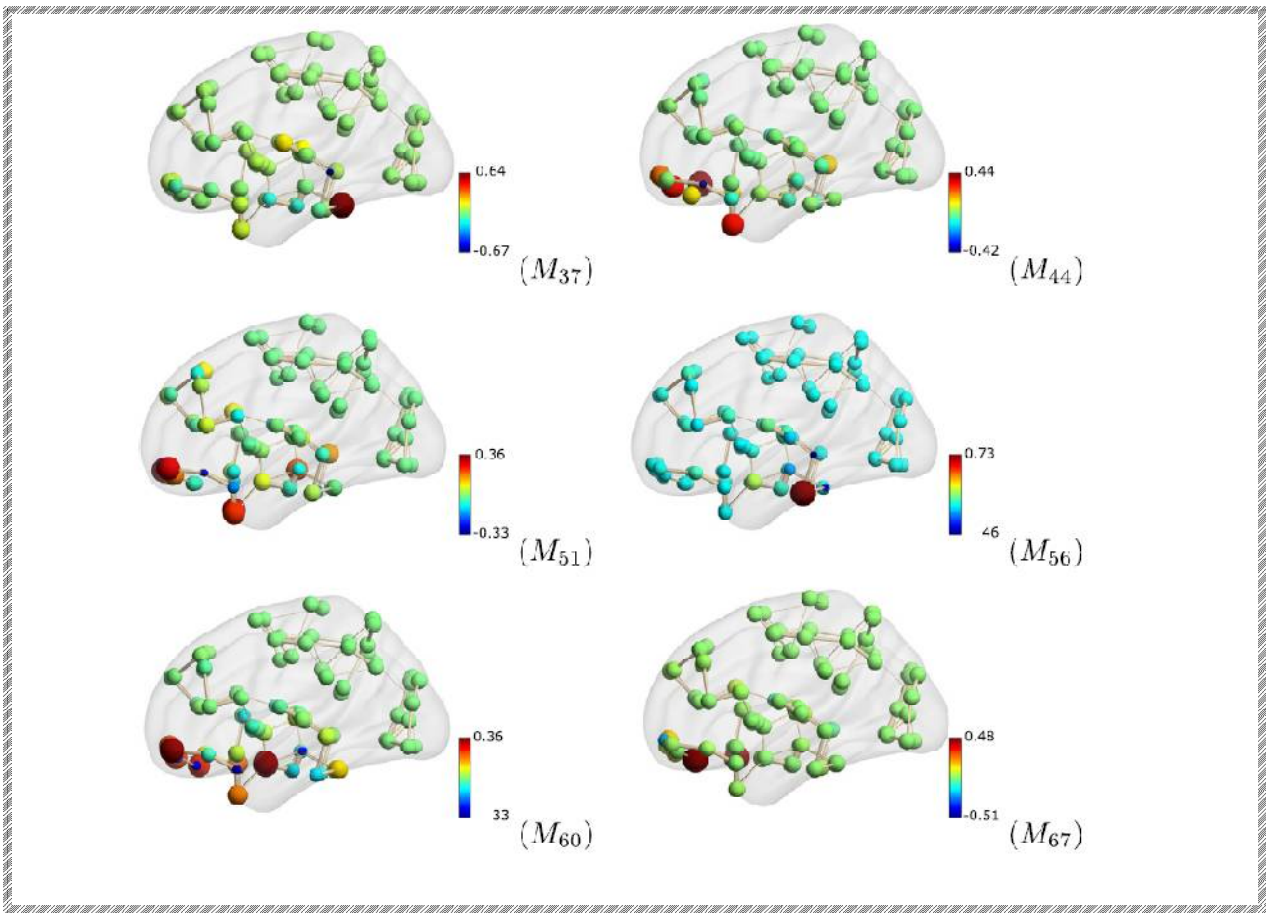
. Decision tree




✓ Subdivisions: related to the log-variance values

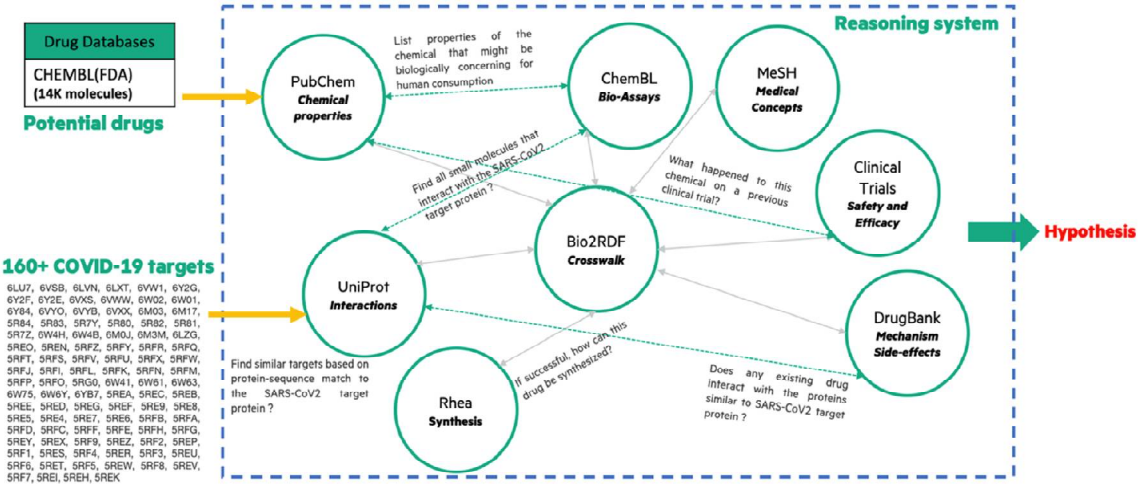
| xAI.Med. | | 2021-05 |
|---|---|---|

ASD




# COVID-19

| xAI.Med. | | 2021-18 |
|---|---|---|

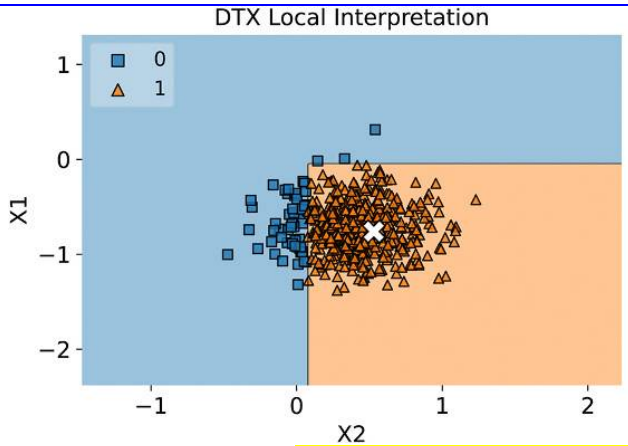


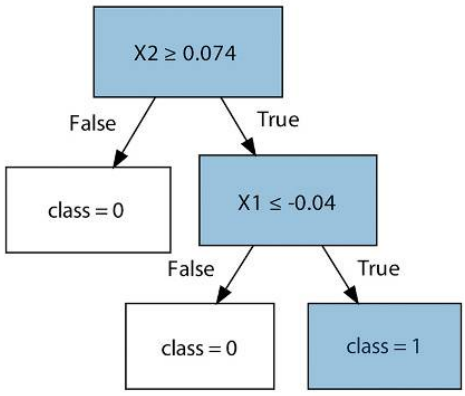

- ! Open knowledge sources
- ! xAI: capable of hypothesis generation using knowledge graphs applied on COVID-19 protein targets.
- ! Computational engine: capable of interactive in-database analytics to query/ impute/ infer new and novel relationships

**xAI.Med.** 2021-22

- o Noise set η generated by DTX around
- o x : instance to be explained

- o Tree structure representing the rules responsible to explain black-box prediction

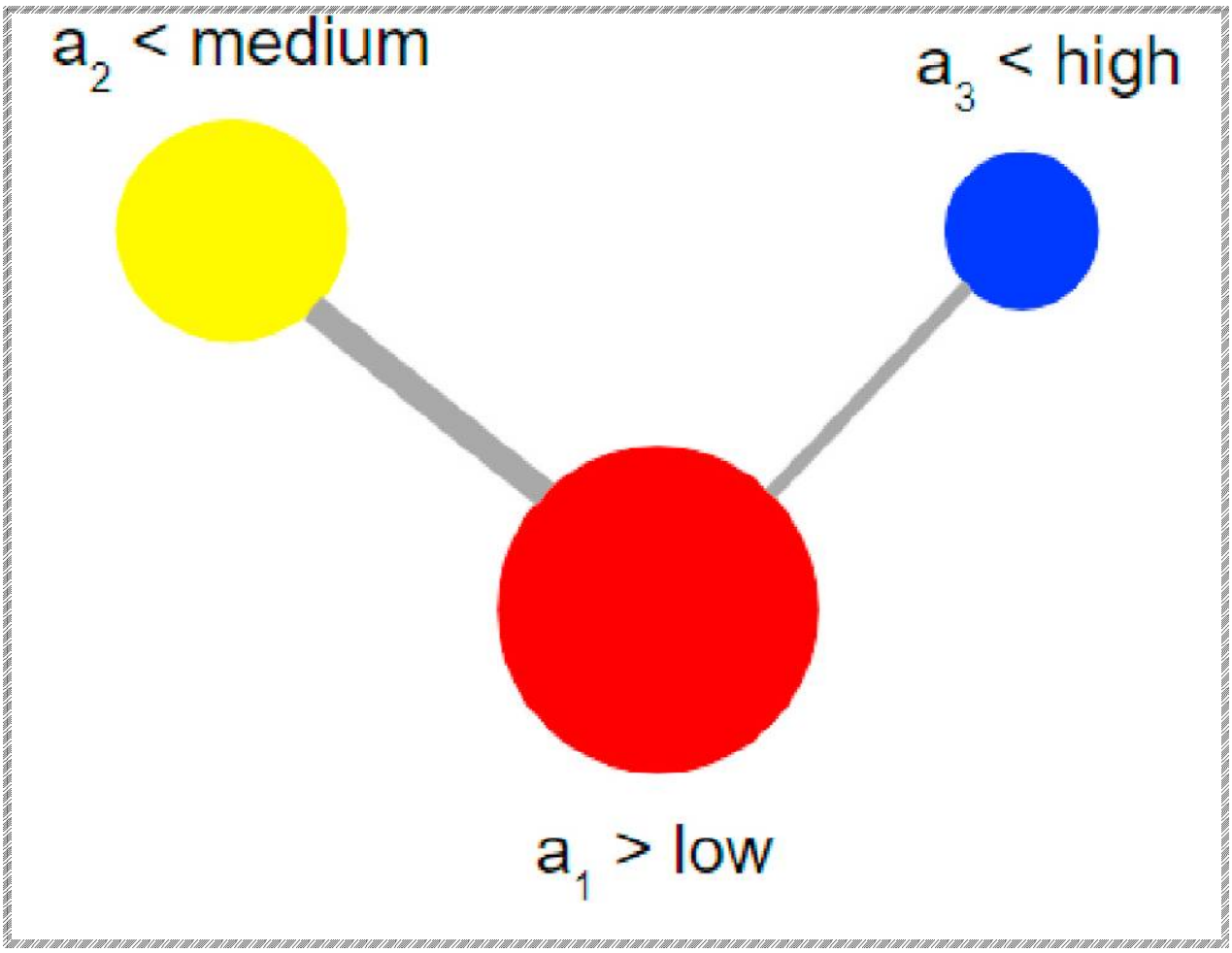



**Decision boundary is based on the DTX output**

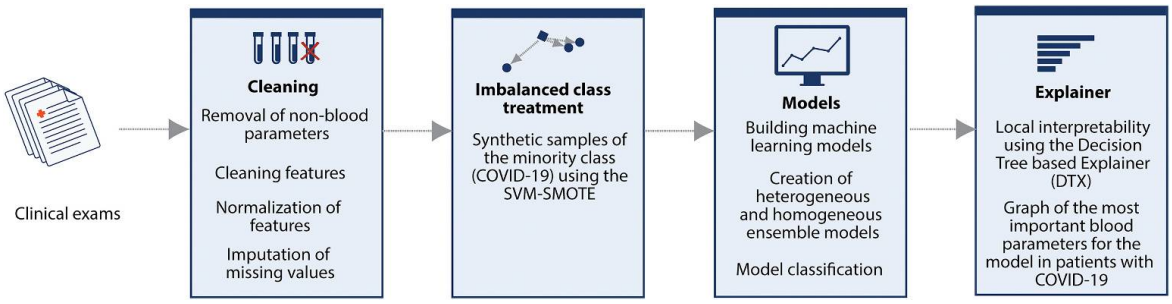
**xAI.Med.** 2021-22

Criteria graph



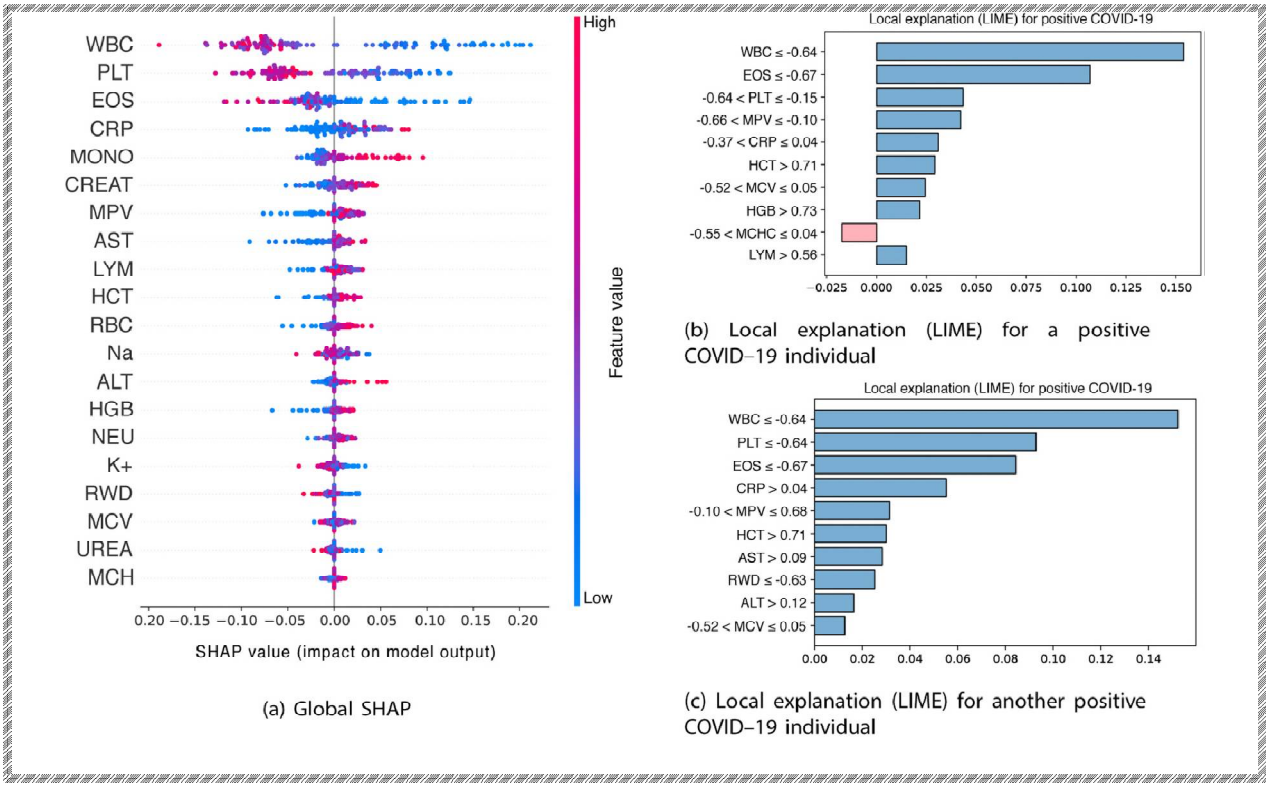



✓ Local explainability
✓ Generating ensemble classifiers






Explanations provided by SHAP and LIME



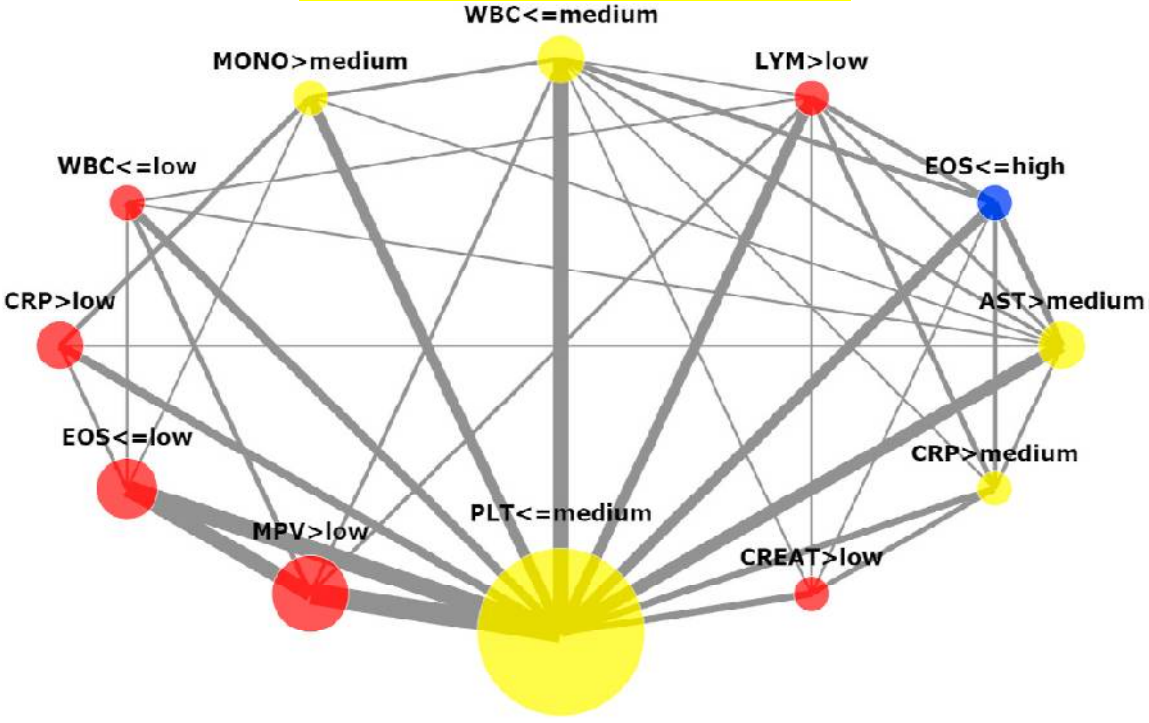

(a) Global SHAP

(b) Local explanation (LIME) for a positive COVID–19 individual

(c) Local explanation (LIME) for another positive COVID–19 individual



Criteria Graph for the decision tree explanations

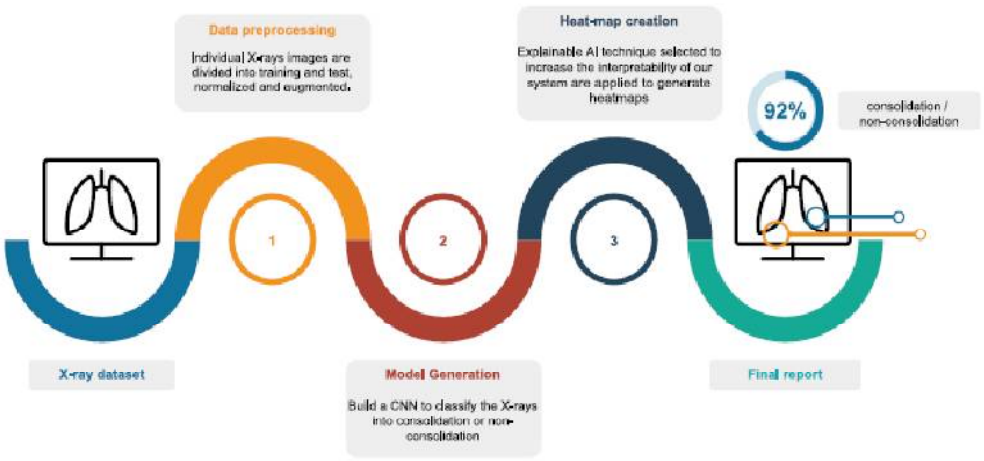


Explanations for the COVID-19 inference of the 12 COVID-19 positive patients in the test set.

| ID | Decision Tree Explanation |
|---|---|
| 1 | EOS ≤ -0.51 and PLT ≤ 0.16 and CRP > -1.74 and EOS ≤ -0.61 and MPV > -0.82 and NEU ≤ -0.42 and MCHC ≤ 1.90 |
| 2 | CRP > -0.43 and EOS > 0.63 and AST ≤ -0.41 and UREA > -0.91 and MCV > 0.12 and CREAT > -0.88 and K+ > -0.52 |
| 3 | EOS > 0.54 and WBC > -0.97 and MCV ≤ -0.13 and ALT ≤ 2.13 and CRP > -0.51 and PLT > -2.98 and HGB > 0.96 and Sodium > 0.12 |
| 4 | AST > -0.43 and CRP > -0.46 and PLT ≤ 0.26 and WBC ≤ -0.44 and LYM > -1.29 and EOS ≤ 0.76 and CREAT > -0.75 and PLT ≤ 0.06 and AST > -0.37 and PLT > -3.57 |
| 5 | EOS > -0.59 and CRP > -0.53 and PLT ≤ -0.33 and CREAT > -0.30 and AST > -0.34 and EOS ≤ 0.39 and MONO > -0.49 and WBC ≤ -0.58 and LYM ≤ 1.11 and HCT > -0.50 |
| 6 | CRP > -0.50 and MPV > -0.99 and EOS ≤ 0.82 and PLT ≤ 0.21 and LYM > -1.17 and CREAT > -0.64 and EOS ≤ 0.37 and WBC ≤ -0.40 and HGB ≤ 0.44 and PLT > -4.22 |
| 7 | CRP > -0.52 and PLT ≤ 0.08 and EOS ≤ -0.07 and HGB > -0.83 and CREAT > -0.87 and EOS ≤ -0.67 and RBC > -1.02 and MONO > -0.16 |
| 8 | HGB > -0.83 and LYM > -1.13 and CRP > -0.47 and CREAT > -0.48 and HCT > -1.09 and EOS ≤ 0.77 and AST > 0.23 and MCV > -6.31 and WBC ≤ -0.88 and PLT ≤ -0.05 |
| 9 | EOS ≤ -0.59 and PLT ≤ -0.08 and MPV > -1.00 and HCT > 0.48 and UREA ≤ 2.35 and WBC ≤ -1.04 and MPV > -0.97 and MCHC > -1.08 |
| 10 | EOS ≤ -0.55 and PLT ≤ 0.13 and MPV > -1.02 and WBC ≤ 0.09 and PLT ≤ -0.11 and ALT > -1.13 and WBC ≤ -0.29 and MONO > -0.28 |
| 11 | EOS > -0.62 and AST > -0.46 and EOS ≤ 0.52 and WBC ≤ -0.47 and CREAT > -0.46 and CRP > -0.68 and PLT ≤ -0.04 and MONO > -0.03 and MCH > -1.77 and AST ≤ 1.04 |
| 12 | PLT ≤ 0.10 and MPV > -1.04 and EOS ≤ -0.54 and MPV > -1.01 and WBC ≤ -0.58 and LYM > -1.48 and MCH > -1.48 and HGB > 1.07 and ALT > -0.54 and MCHC > -0.22 |

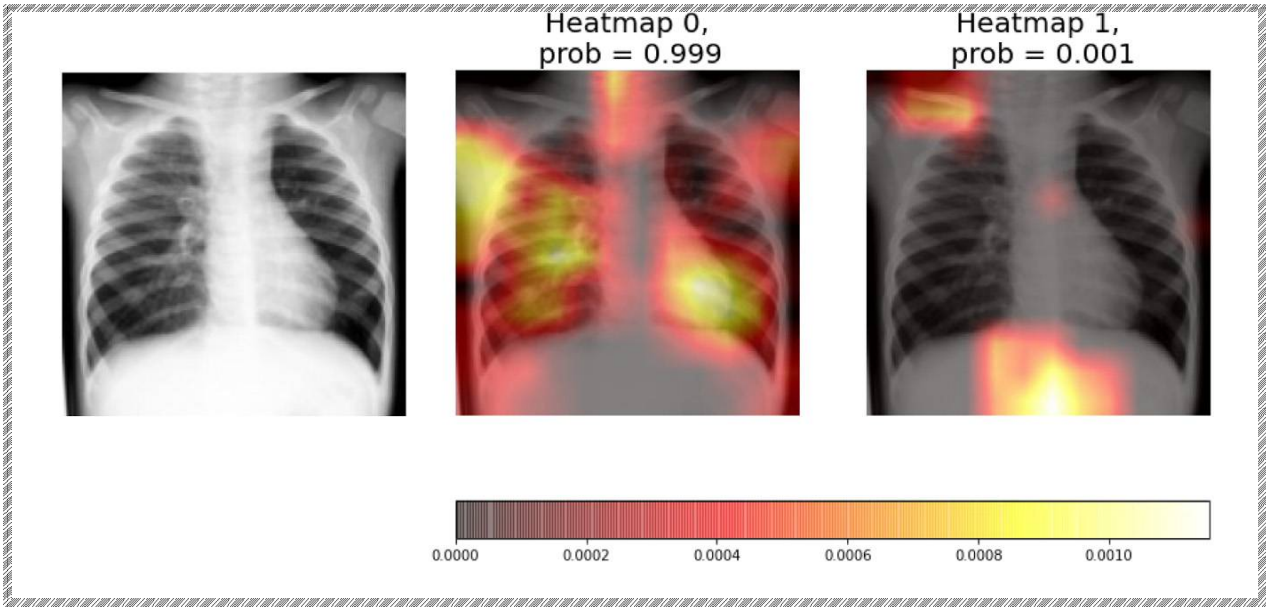


. Data flow diagram (I → [Methods] → output






Heatmaps generated with an individual CNN (Arch1)
for a non-consolidation test X-ray (sample 1).

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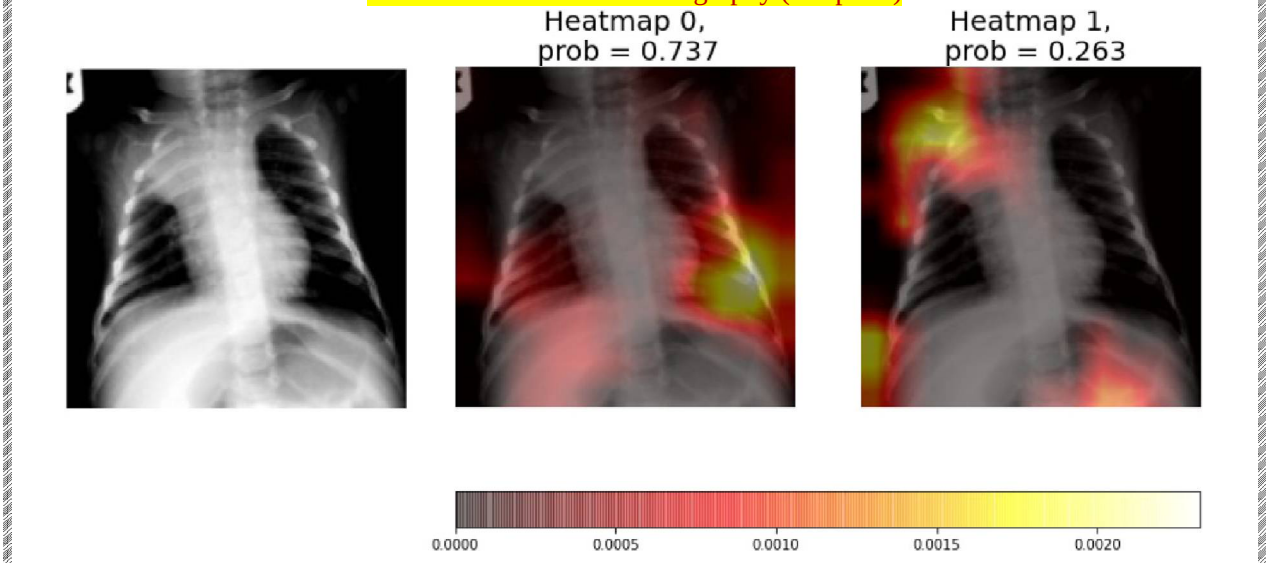
|---|---|---|

Heatmaps generated with an individual CNN (Arch1)
for a consolidation test radiography (sample 1)

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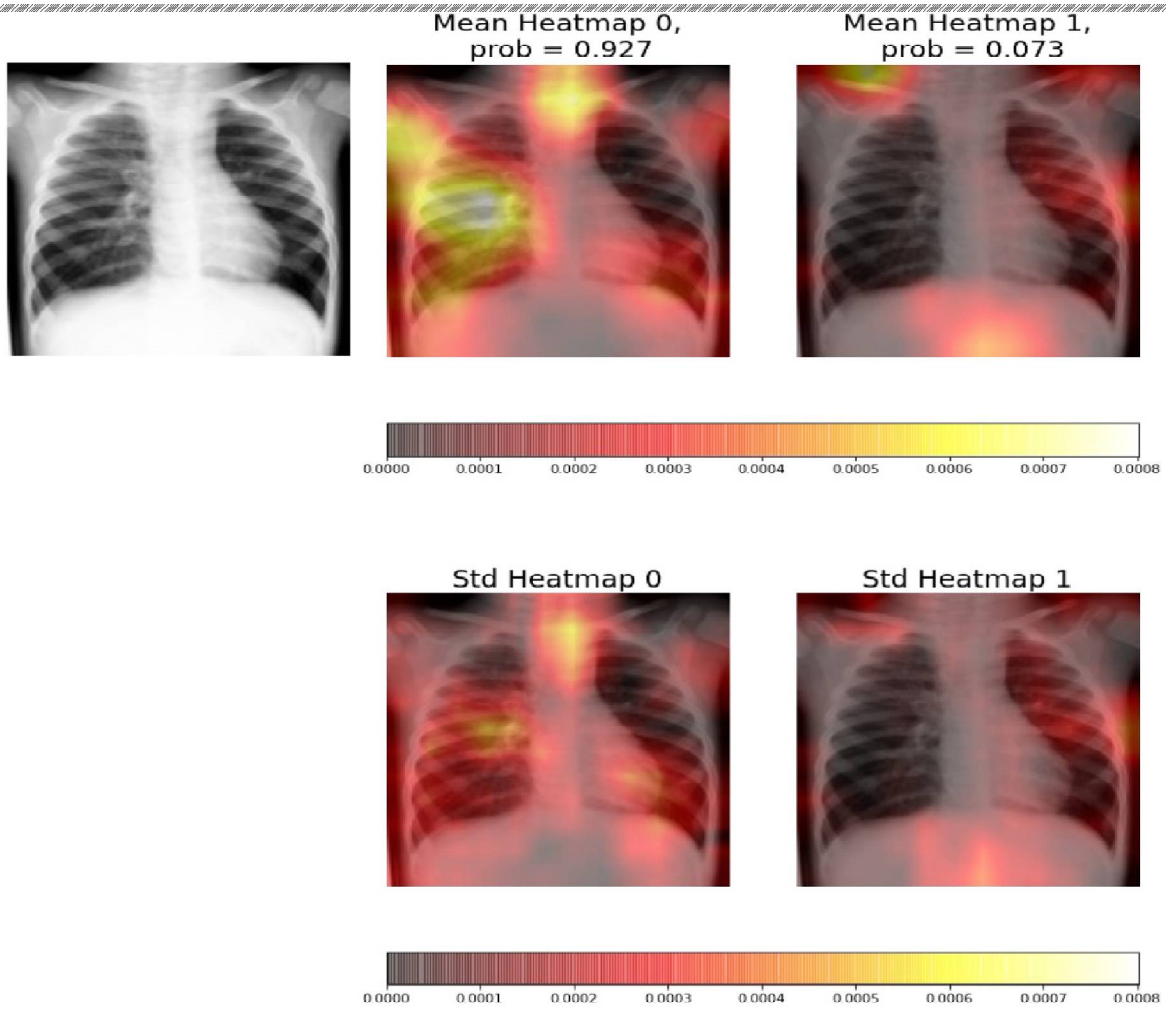
|---|---|---|

. Heatmaps of a non-consolidation sample 1




Left side, Neuron 0, : heatmaps for the non-consolidation class,
right side, Neuron 1: heatmaps for consolidation class for five individual CNNs.

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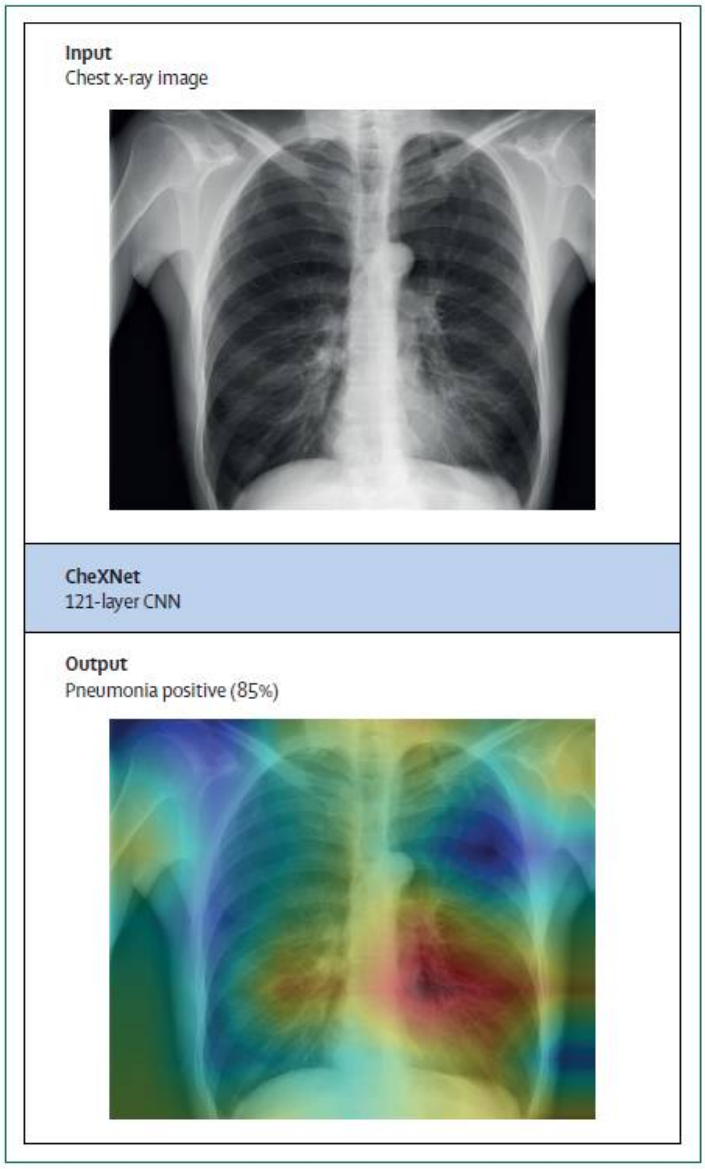
|---|---|---|

Heat map -- pneumonia in chest x-rays




- ✓ Brighter colours (red) :regions with higher levels of importance
- ✓ darker colours (blue) :regions with lower levels of importance

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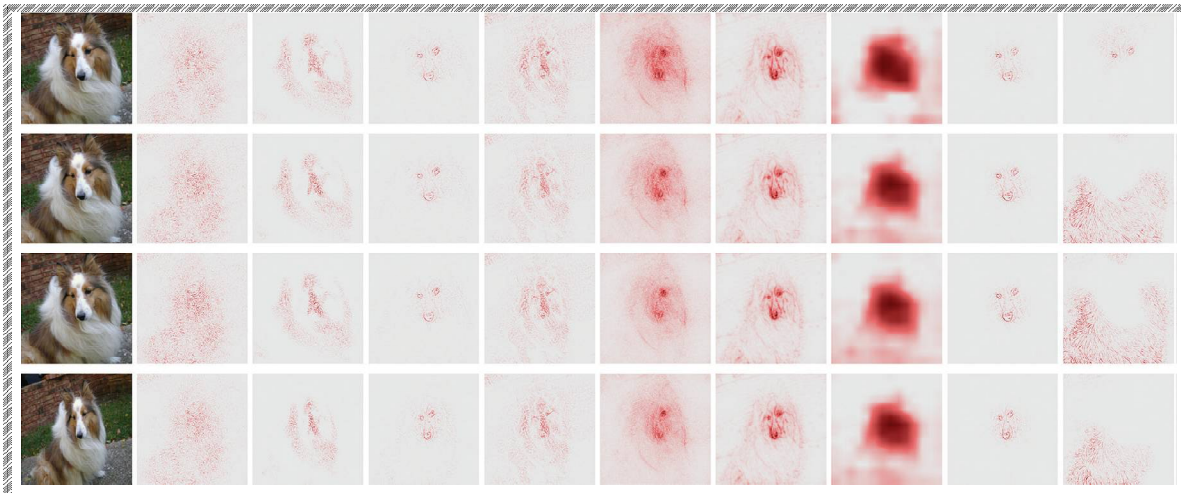
|---|---|---|

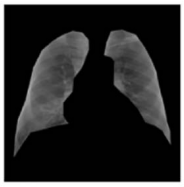
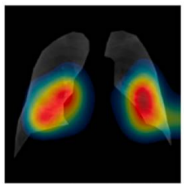
Saliency maps



- ✓ Top row: correctly classified image and saliency maps
- ✓ Rows 2 to 4 : incorrectly classified images after adversarial perturbations.

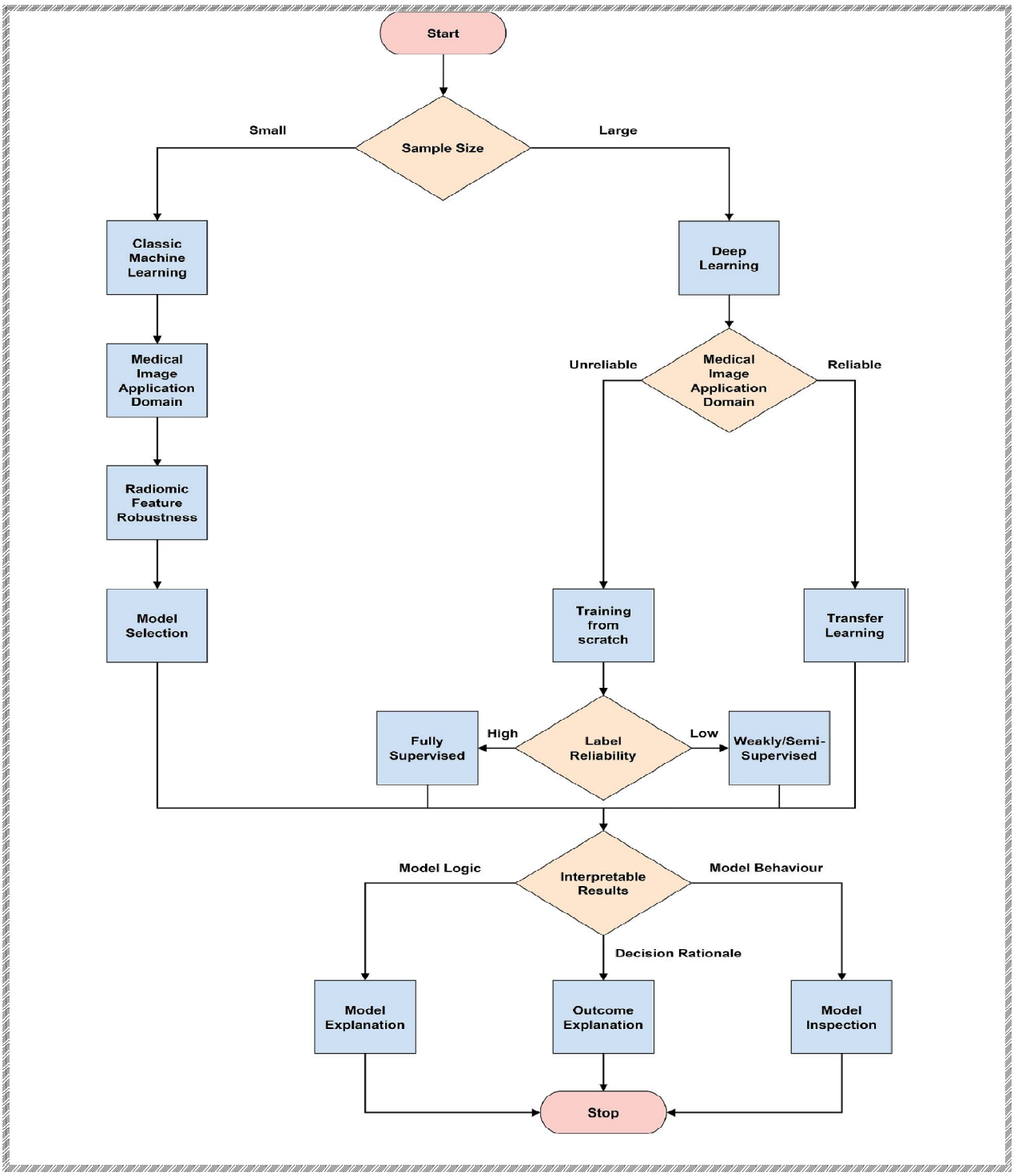


AI, xAI in medicine

| Task | Input data | AI technique | AI output | XAI output |
|---|---|---|---|---|
| Lesion Classification | Clinical features + Imaging features | Machine Learning (Feature selection + SVM classification) | Classification label (Malignant vs. Benign) | Classification label + Most important features for AI model: • Lesion heterogeneity • Lesion entropy • Family history |
| Pneumonia Diagnosis | X-Ray Imaging  | Deep Learning (Convolutional Neural Networks) | Classification label (Pneumonia vs. Healthy) | Classification label + Activation map  |

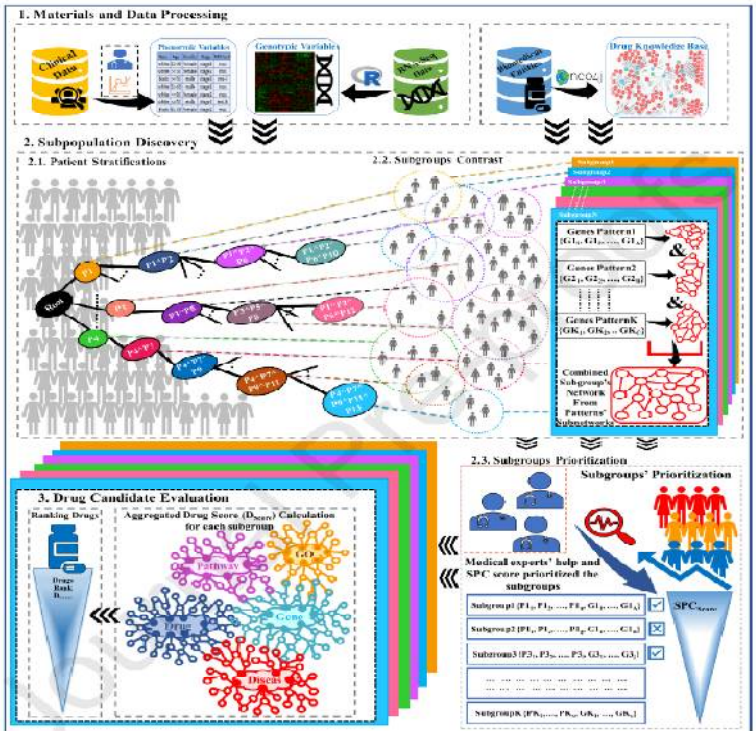


Classic machine learning and deep learning models in medicine


Start
Sample Size
Small
Large
Classic Machine Learning
Deep Learning
Medical Image Application Domain
Unreliable
Medical Image Application Domain
Reliable
Radiomic Feature Robustness
Model Selection
Training from scratch
Transfer Learning
Fully Supervised
High
Label Reliability
Low
Weakly/Semi-Supervised
Model Logic
Interpretable Results
Model Behaviour
Decision Rationale
Model Explanation
Outcome Explanation
Model Inspection
Stop

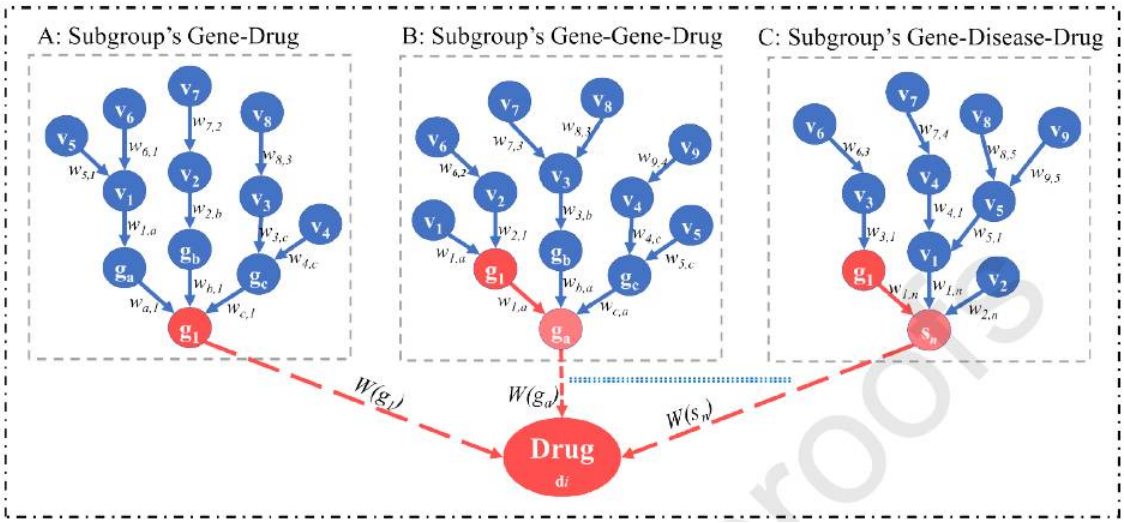
# Drugs

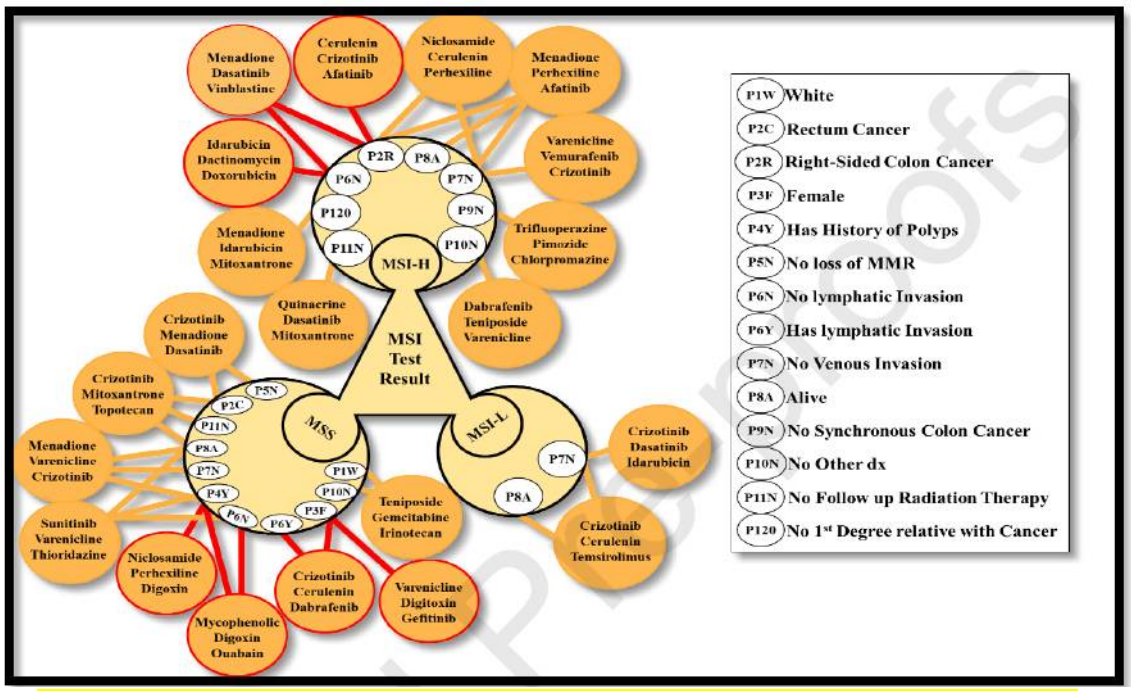
## Drug Repositioning Framework






## Aggregated drug score calculation for each drug






MSI test result-related subgroups with the top three recommended drugs for each subgroup

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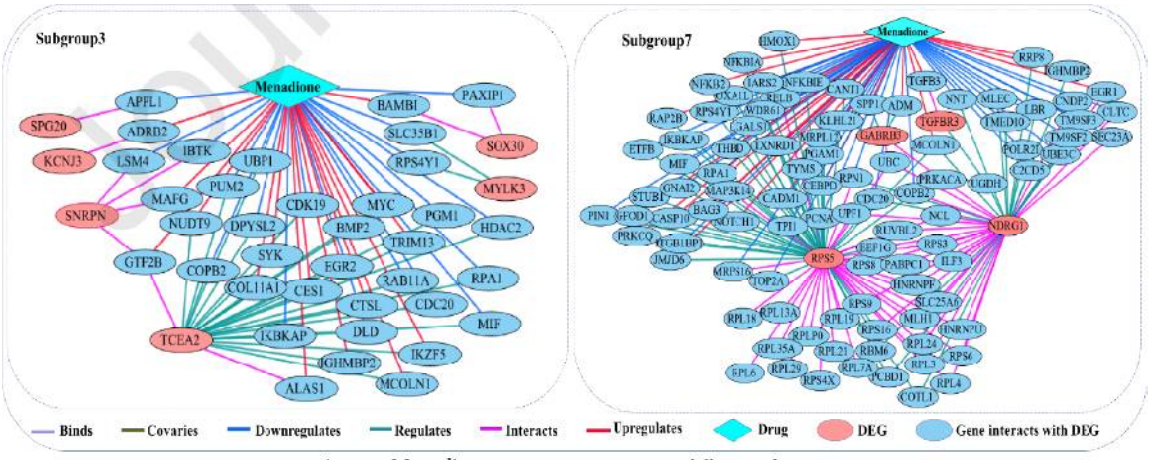
|---|---|---|

Menadione gene interactions in two different subgroups

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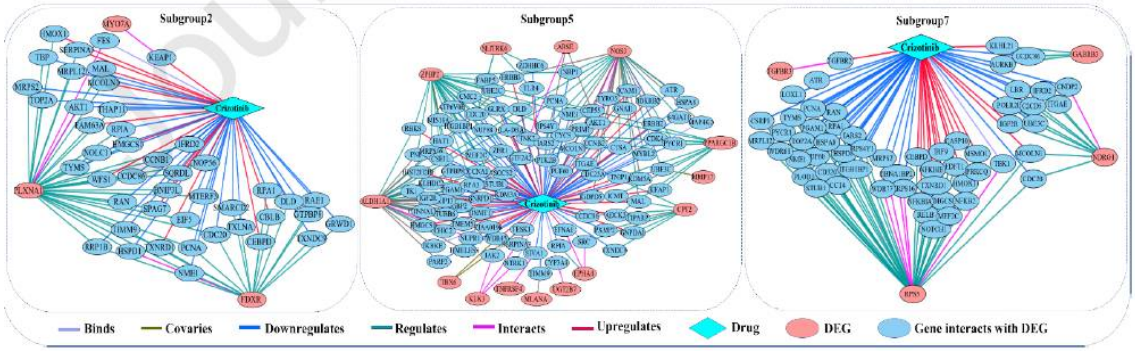
|---|---|---|

Crizotinib gene interactions in three different subgroups






randomized analyses

| | Subgroups | DR Top Drugs | Randomized Top Drugs |
|---|---|---|---|
| 1 | MSI-H & no lymphatic invasion | Idarubicin | Tetrahydrobiopterin |
| | | Dactinomycin | Diethylstilbestrol |
| | | Doxorubicin | Fluphenazine |
| 2 | MSI-H & right-sided colon | Cerulenin | Streptozocin |
| | | Crizotinib | Tetrahydrobiopterin |
| | | Afatinib | Metaxalone |
| 3 | MSI-H & right-sided colon & no lymphatic invasion | Menadione | Testosterone |
| | | Dasatinib | Pseudoephedrine |
| | | Vinblastine | Paliperidone |
| 4 | MSS & female | Varenicline | Terazosin |
| | | Digitoxin | Isoflurane |
| | | Gefitinib | Fospropofol |
| 5 | MSS & female & have lymphatic invasion | Crizotinib | Imatinib |
| | | Cerulenin | Simvastatin |
| | | Dabrafenib | Bortezomib |
| 6 | MSS & a history of colon polyp | Niclosamide | Trilostane |
| | | Perhexiline | Doxylamine |
| | | Digoxin | Flucloxacillin |
| 7 | MSS & a history of colon polyp & No venous invasion | Menadione | Diclofenac |
| | | Varenicline | Digoxin |
| | | Crizotinib | Progesterone |

# Toxicology
# Human and Computer Agreement

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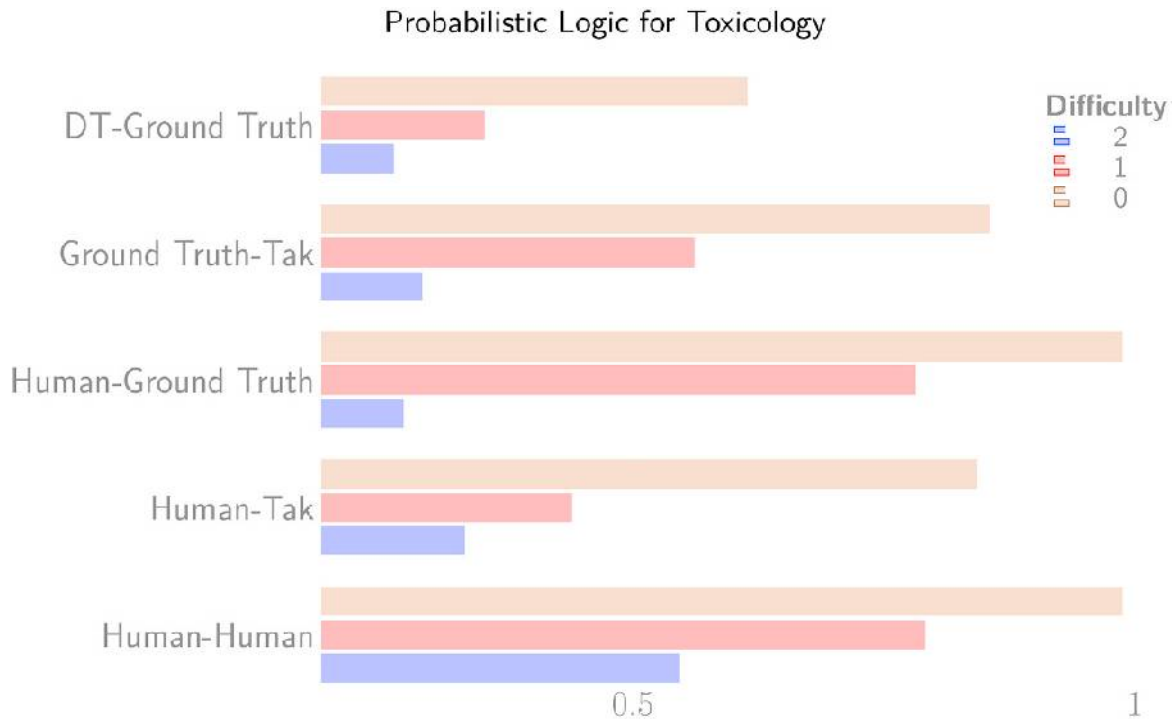
Human and Computer Agreement




- ✓ X-axis denotes Cohen's κ.
- ✓ Y-axis denotes pair;
- ✓ Ground Truth denotes labels generated while creating data set
- ✓ Hue indicates difficulty of presentation

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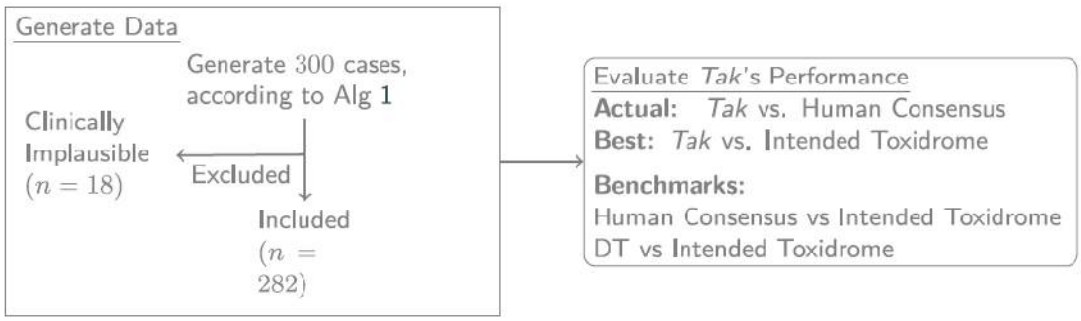
Tak: combination of probabilistic logic algorithm and knowledge base
DT: decision



Listing 1: Example rule that represents distribution of salivarates in the general population

```
0.10::salivation(X,decreased);
0.10::salivation(X,increased);
0.80::salivation(X,usual).
```

number before the two colons: probability with which the probability is true.
A;B means "A or B but notboth".

assigning the likelihood of one toxidrome over another given thatthe patient is manifesting a symptom.

```
4*P::hasToxidrome(X,sympathomimetic);
P::hasToxidrome(X,serotonergic) :-
mentalStatus(X,agitated), P is 0.2.
```

- A :- B means that B is true if A is true
- ✓ The function mentalStatus(X,agitated) is true if patient X is agitated.

The function hasToxidrome(X,Y) is true if patient X manifeststoxidrome Y

Rule Defining the Cholinergic Toxidrome

```
hasToxidrome(X,cholinergic) :-
salivation(X, increased),
urination(X, increased), %i.e. polyuria
pupilDiameter(X,small).
```

The relative probabilities across rules were chosen to reflect the perceived relative prevalence of each clinical finding

- ! Report from American Association of Poison Control Centers on the relative prevalence of each poisoning in the US to estimate the prior probability of each toxidrome prevalence of many
- o Physical findings, for example the rates of salivation in the general population, are not known.
- o Nor is it known that a patient is precisely four times more likely to suffer from a sympathomimetic toxidrome as opposed to serotonin toxicity if the patient becomes agitated after an unknown ingestion.
- o The magnitudes were chosen, in conjunction with the consensus of experts, to reflect implicit components of clinical response

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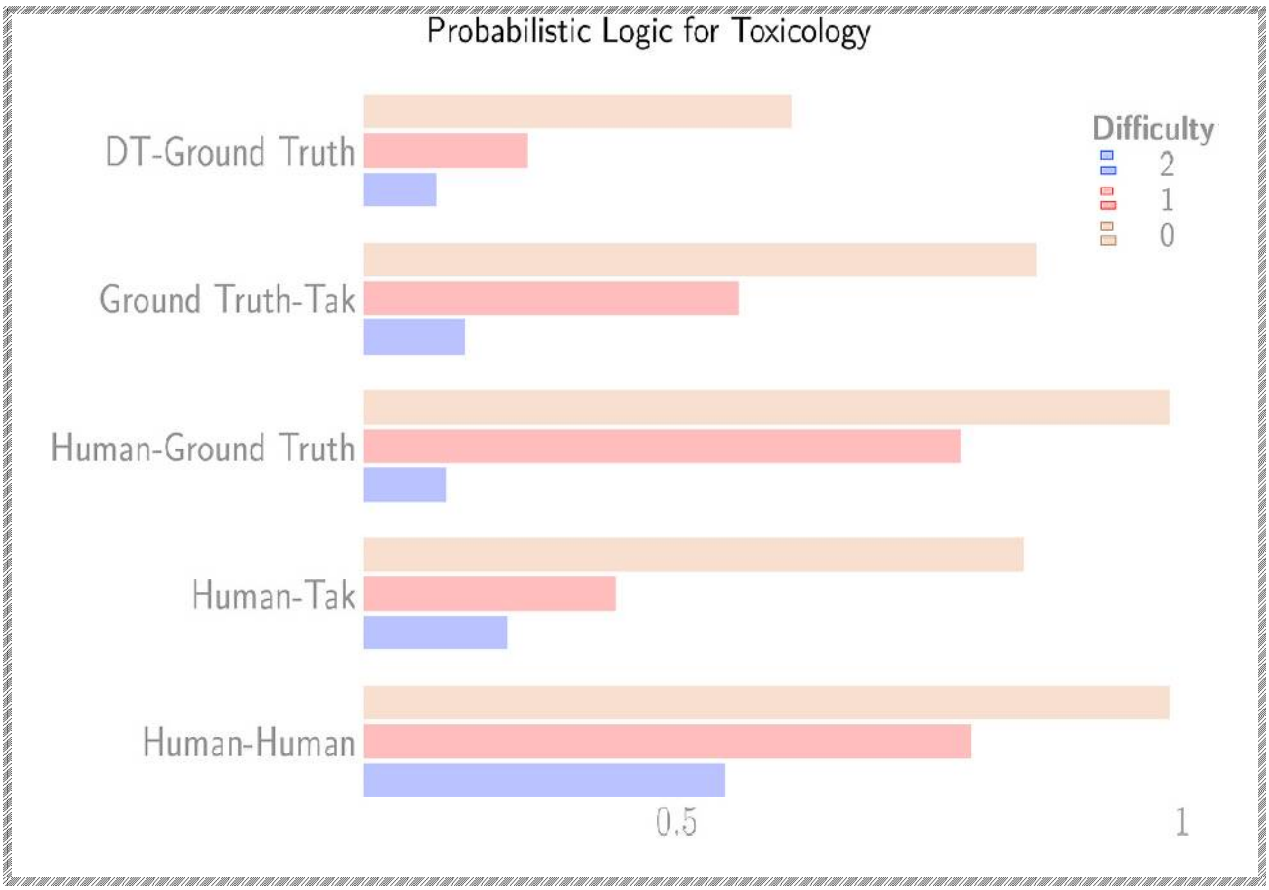
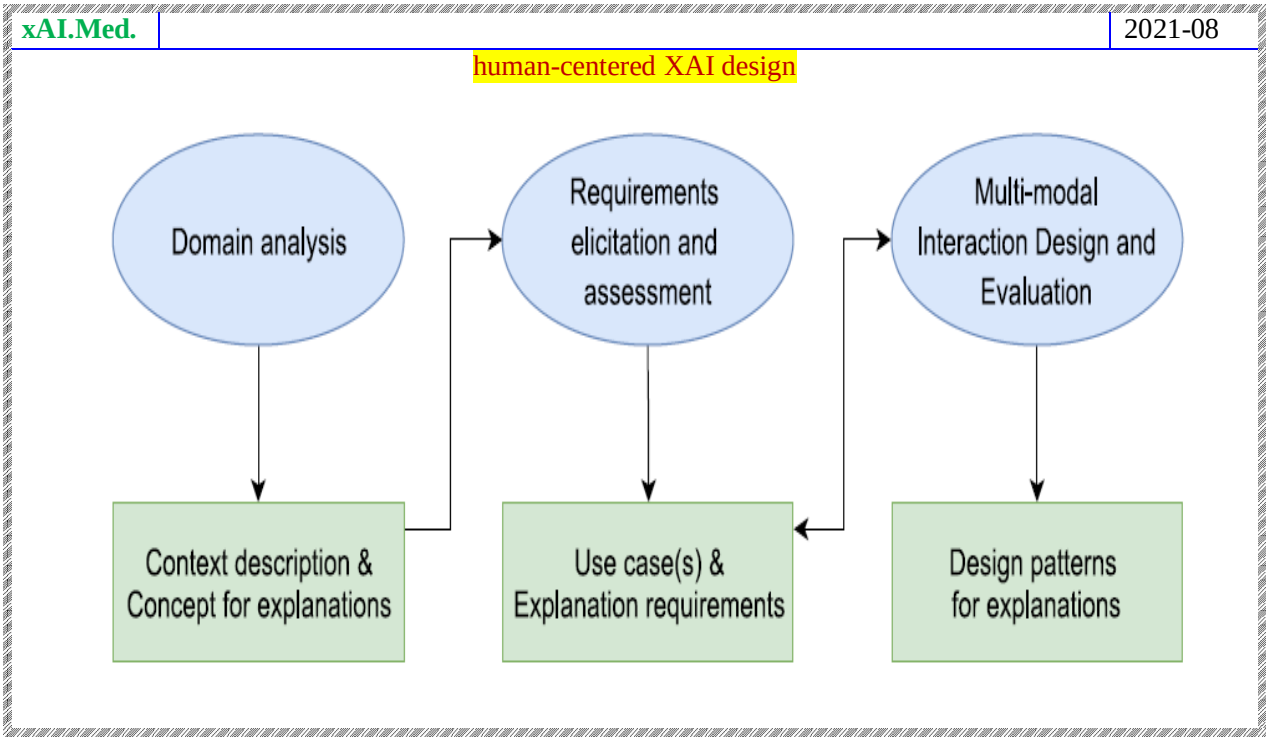
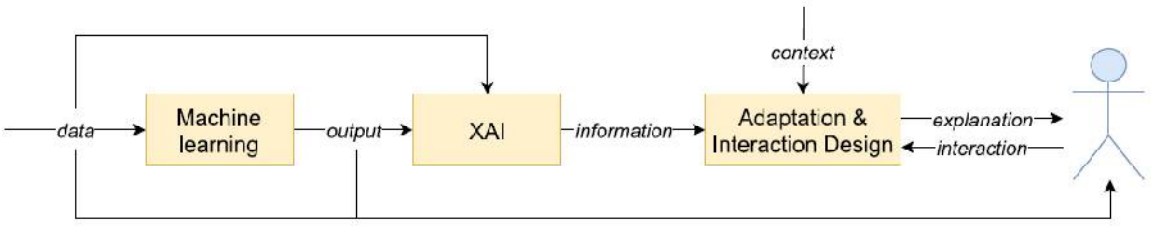





human-centered XAI design

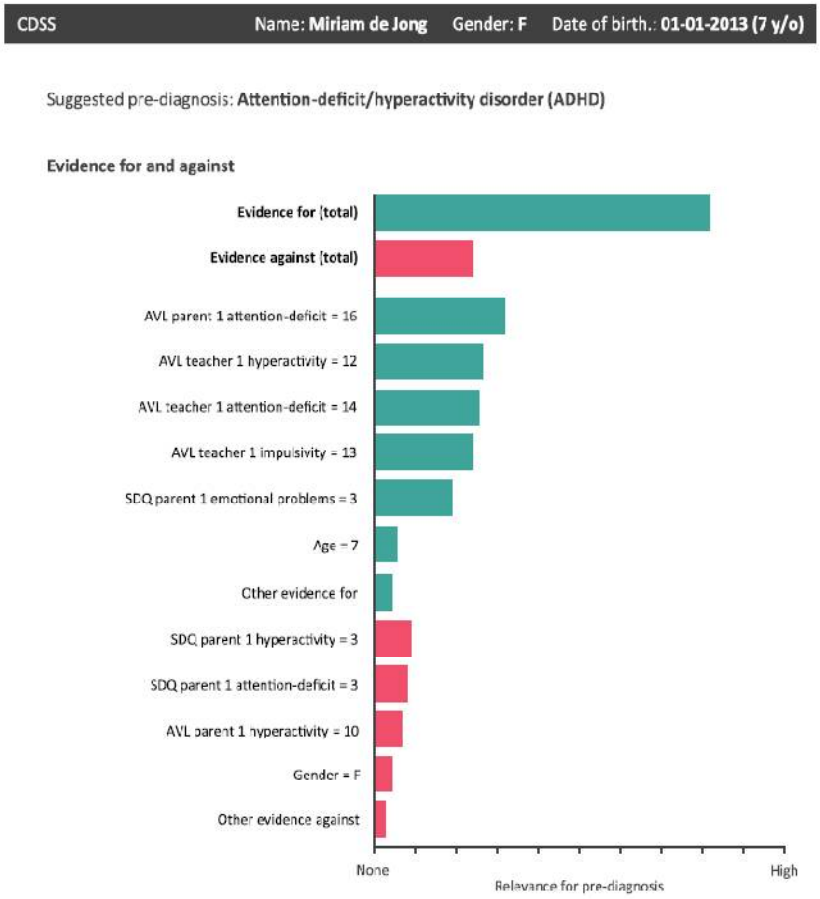


Framework for explanation generation and communication to a user






UI design example

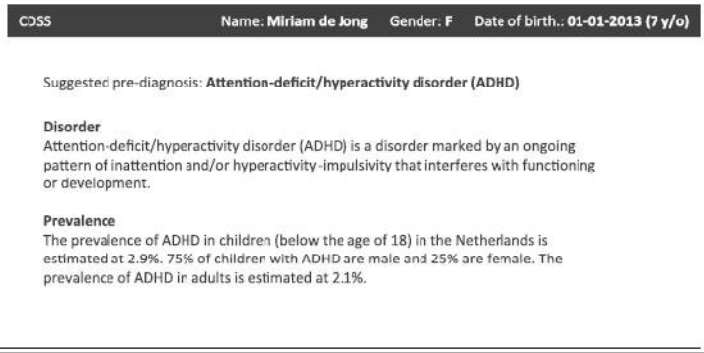


DP 1: Class information.

| | |
|---|---|
| Problem description | The user needs to know:<br>- A description of the class<br>- The prevalence of the class |
| UI design example | |


| | |
|---|---|
| Problem description | The user needs to know:<br>- A description of the class<br>- The prevalence of the class |


UI design example

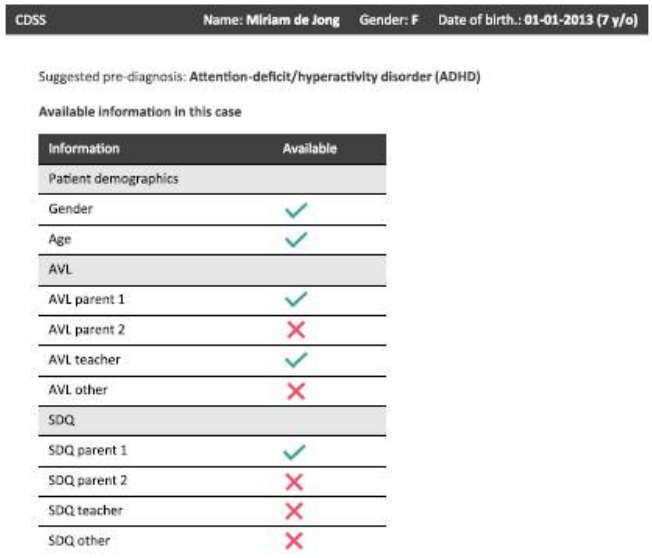



DP 2: Available/relevant information.

| | |
|---|---|
| Problem description | The user needs to know:<br>- The information that is used to make the classification<br>- The information that is relevant in making this type of classification |
| UI design example | |

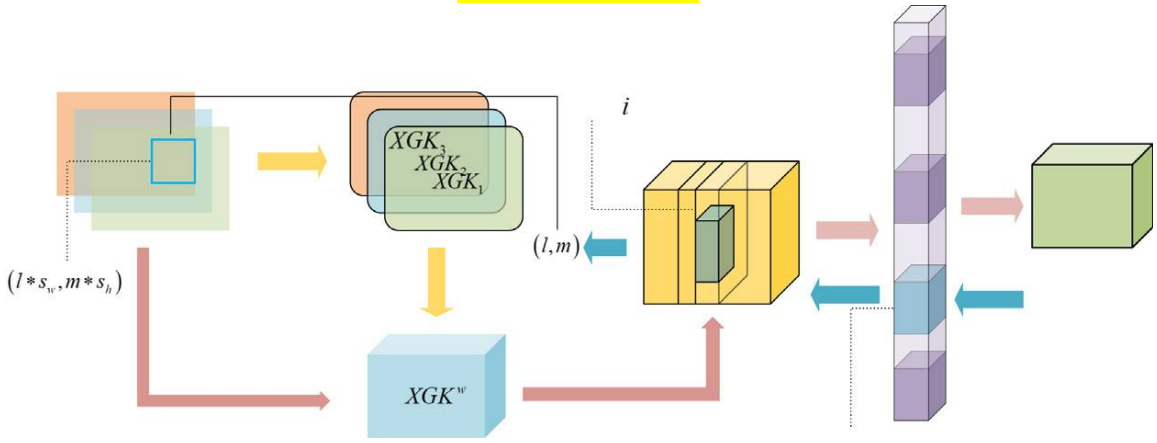

| | |
|---|---|
| Problem description | The user needs to know:<br>- The information that is used to make the classification<br>- The information that is relevant in making this type of classification |


UI design example

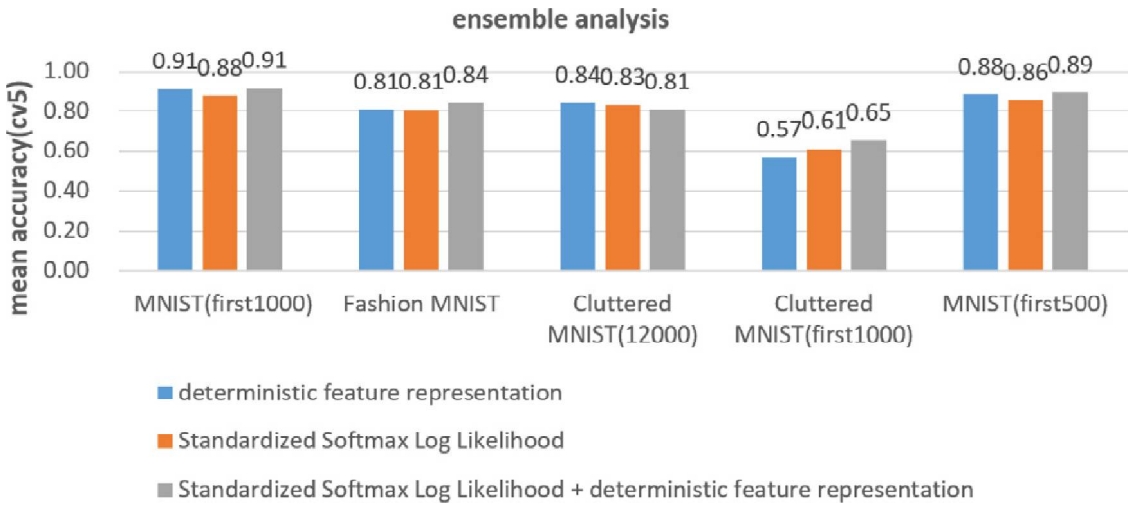



| Information | Available |
|---|---|
| Patient demographics | |
| Gender | ✓ |
| Age | ✓ |
| AVL | |
| AVL parent 1 | ✓ |
| AVL parent 2 | ✗ |
| AVL teacher | ✓ |
| AVL other | ✗ |
| SDQ | |
| SDQ parent 1 | ✓ |
| SDQ parent 2 | ✗ |
| SDQ teacher | ✗ |
| SDQ other | ✗ |

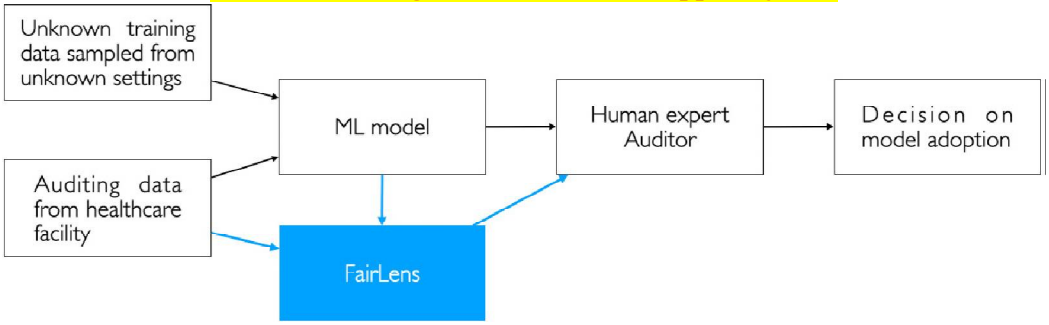
XEGK (explainable ensemble Gaussian kernel) model
with SHAP feedback



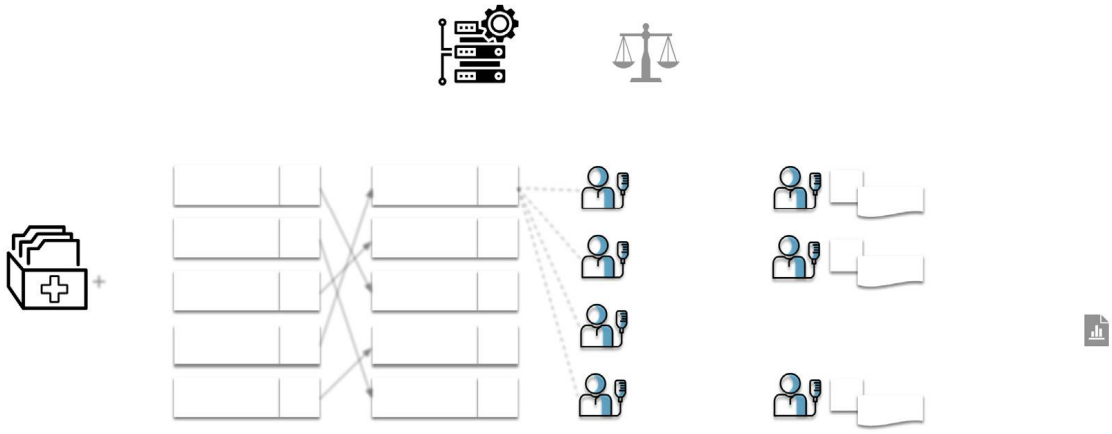



**FairLens**
**Tool for auditing a clinical decision support system**



FairLens pipeline: a tool to support human experts



**which health conditions are more often misclassified**

**why**

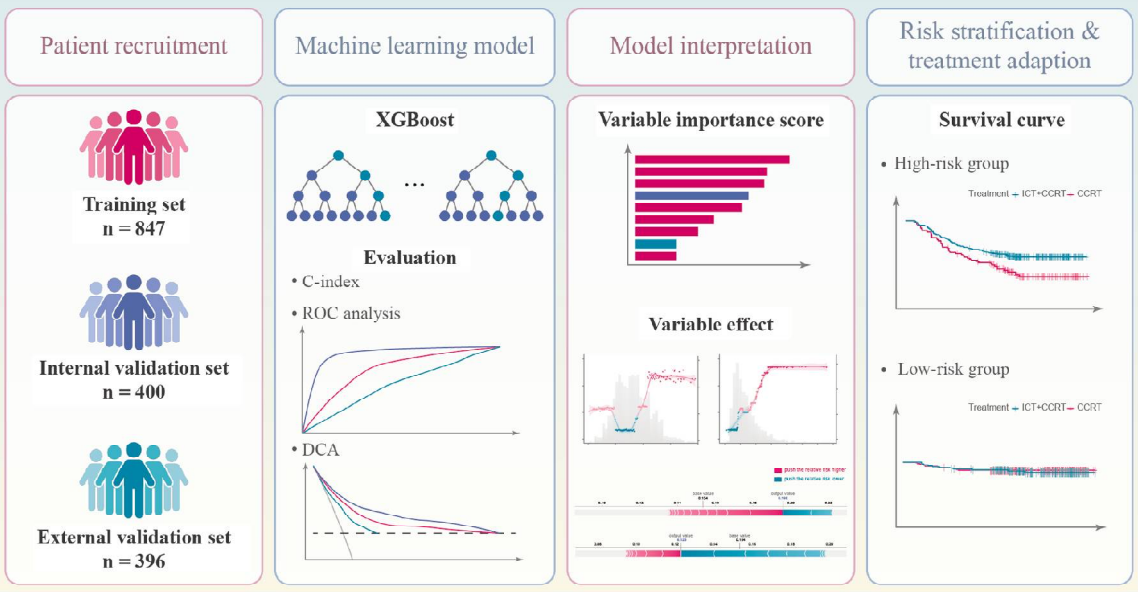


Simple generalization in pseudo-code for a counterfactual explanation

IF *2-Hour_serum_insulin_level* $==^{9}$ $\xi$
THEN print "If your 2-Hour serum insulin level was" $\xi$
", you would have score of 0.51"
ELSE print "Your 2-Hour serum insulin level is not" $2-Hour_serum_insulin_level
", please see your doctor."



Method- flow




- XGBoost, EXtreme Gradient Boosting;
- DCA, decision curve analysis;
- C-index, concordance index;
- ROC, receiver operating curve;
- ICT, induction chemotherapy;
- CCRT, concurrent chemoradiotherapy;

# Health-care

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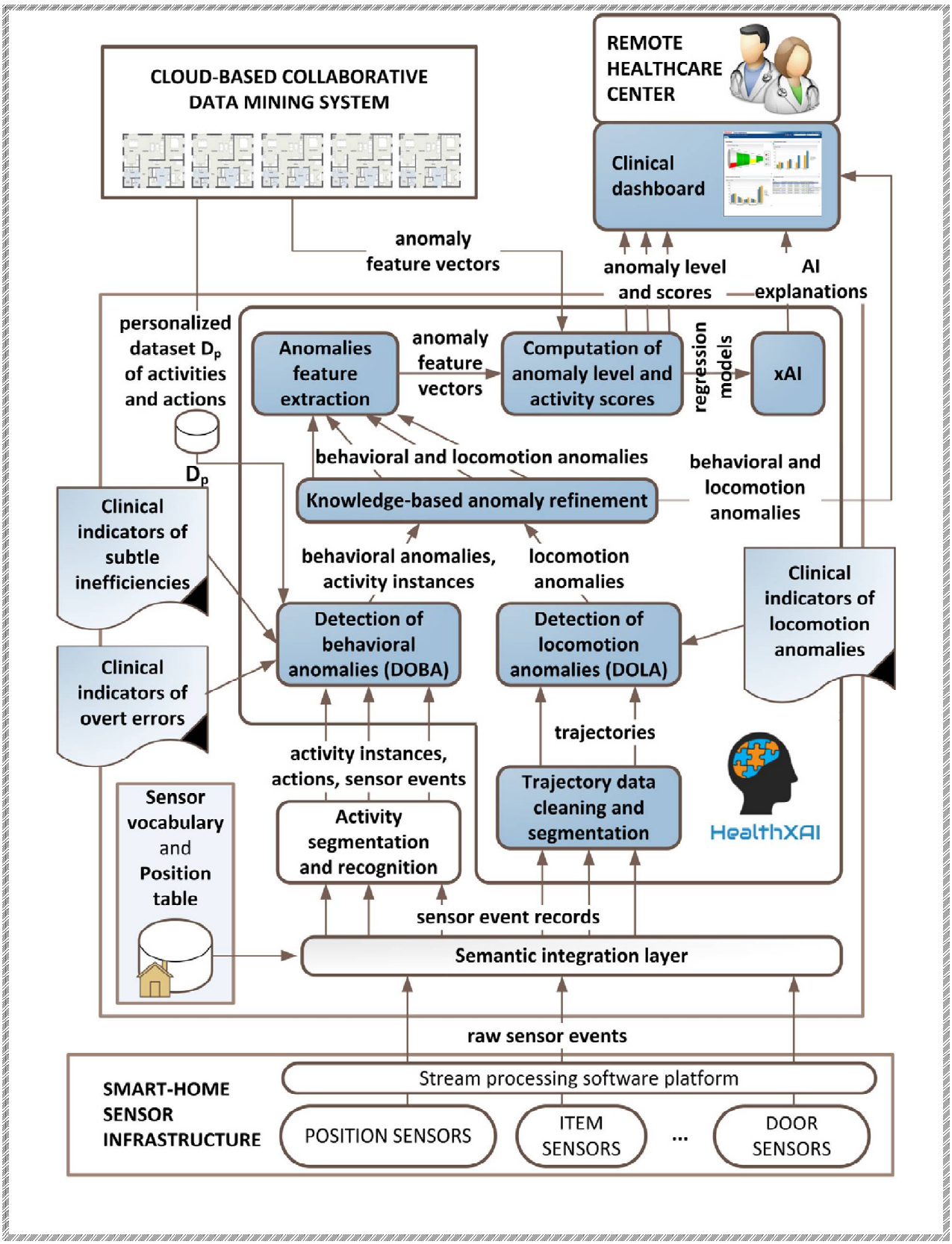
|---|---|---|

HealthXAI architecture

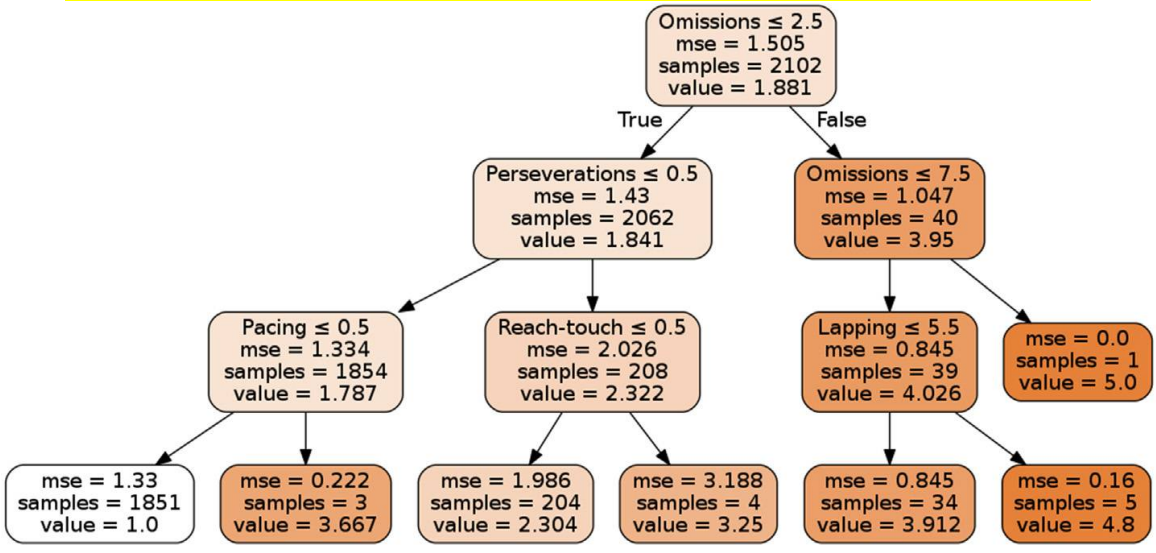

CLOUD-BASED COLLABORATIVE DATA MINING SYSTEM
REMOTE HEALTHCARE CENTER
Clinical dashboard
anomaly feature vectors
anomaly level and scores
AI explanations
personalized dataset $D_p$ of activities and actions
$D_p$
Anomalies feature extraction
anomaly feature vectors
Computation of anomaly level and activity scores
regression models
xAI
behavioral and locomotion anomalies
Knowledge-based anomaly refinement
behavioral and locomotion anomalies
Clinical indicators of subtle inefficiencies
behavioral anomalies, activity instances
locomotion anomalies
Clinical indicators of locomotion anomalies
Detection of behavioral anomalies (DOBA)
Detection of locomotion anomalies (DOLA)
Clinical indicators of overt errors
trajectories
activity instances, actions, sensor events
Trajectory data cleaning and segmentation
HealthXAI
Sensor vocabulary and Position table
Activity segmentation and recognition
sensor event records
Semantic integration layer
raw sensor events
SMART-HOME SENSOR INFRASTRUCTURE
Stream processing software platform
POSITION SENSORS
ITEM SENSORS
...
DOOR SENSORS

Lookup table of HealthXAI modules and data structures.

| Module / data structure |
|---|
| Activity instances and actions |
| Activity segmentation and recognition |
| AI explanation |
| Anomalies feature extraction |
| Anomaly feature vector |
| Anomaly level and scores |
| Behavioral anomalies |
| Clinical indicators of locomotion anomalies |
| Computation of anomaly level and activity scores |
| Detection of behavioral anomalies (DOBA) |
| Detection of locomotion anomalies (DOLA) |
| Knowledge-based anomaly refinement |
| Locomotion anomalies |
| Overt errors |
| Personalized dataset $D_p$ of activities and actions |
| Regression model |
| Semantic integration layer |
| Sensor event record |
| Sensor vocabulary and Position table |
| Stream processing software platform |
| Subtle inefficiencies |
| Trajectory data cleaning and segmentation |
| Trajectory segments |
| xAI |



learned model of a random tree used for the prediction of the anomaly score of an activity




- ✓ Input: feature vector of the patient's activity
- o Starting from the root
  - o Regression algorithm evaluates the rules conditions based on the feature vector of the patient's activity
  - o If the condition is verified, it evaluates the condition of the left child;
  - o Otherwise, it evaluates the one of the right child.

- Mechanism repeated until a leaf is reached.
- ✓ OutPut :Leaf contains predicted value

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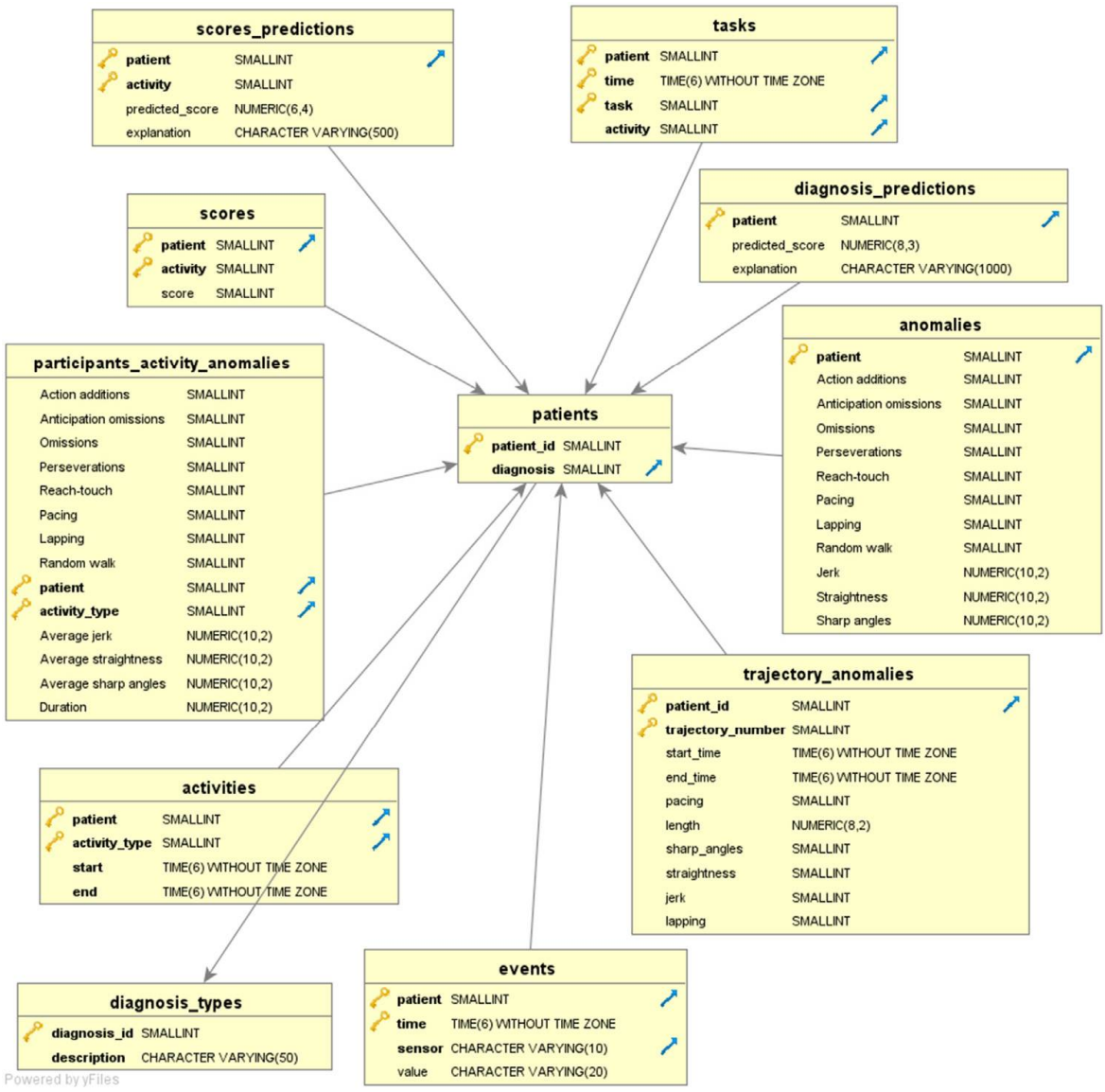
|---|---|---|

Tables of HealthXAI database

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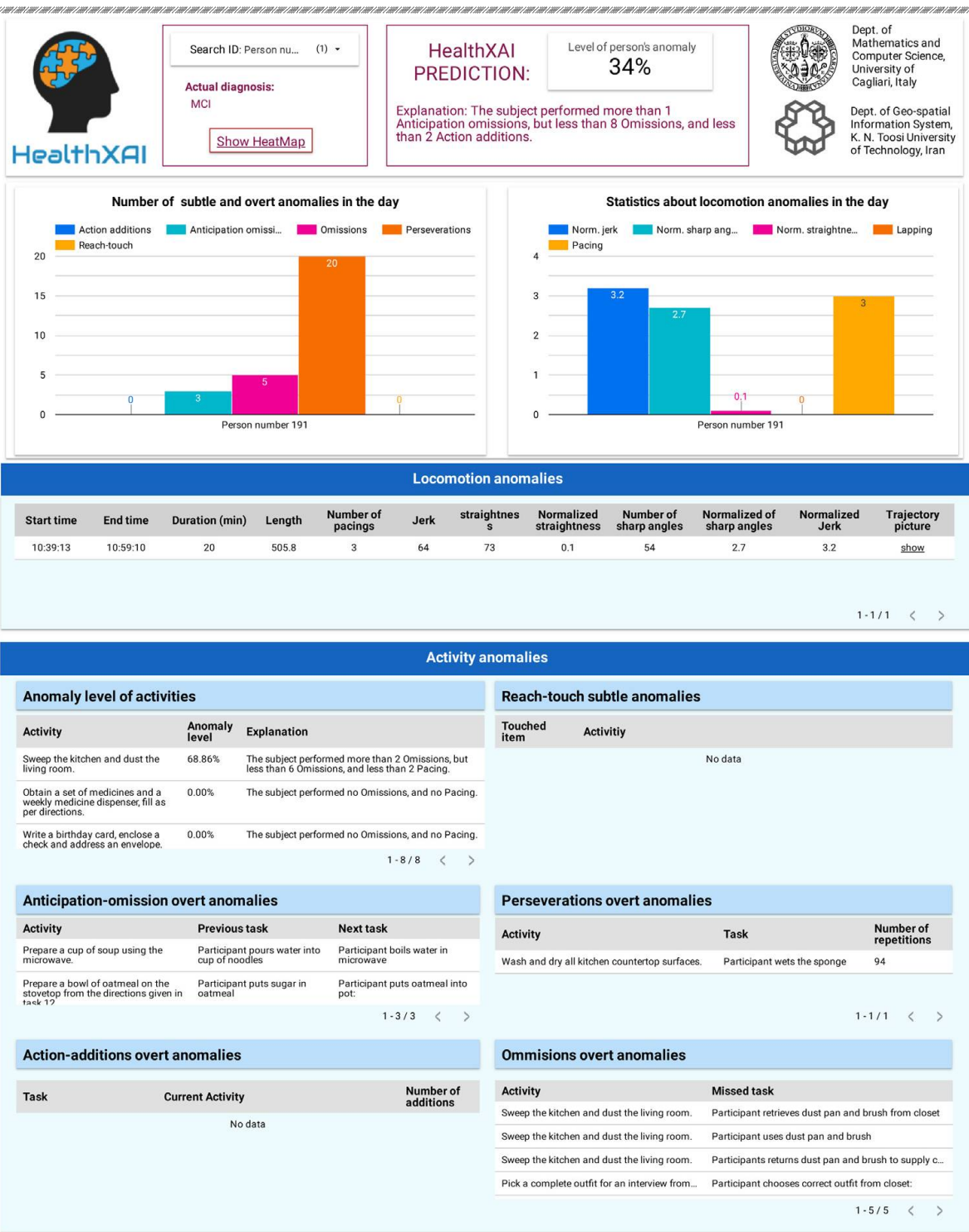
|---|---|---|

HealthXAI dashboard---screenshot


HealthXAI
Search ID: Person nu... (1)
Actual diagnosis:
MCI
Show HeatMap
HealthXAI PREDICTION:
Level of person's anomaly
34%
Explanation: The subject performed more than 1 Anticipation omissions, but less than 8 Omissions, and less than 2 Action additions.
Dept. of Mathematics and Computer Science, University of Cagliari, Italy
Dept. of Geo-spatial Information System, K. N. Toosi University of Technology, Iran
Number of subtle and overt anomalies in the day
Action additions
Anticipation omissi...
Omissions
Perseverations
Reach-touch
20
15
10
5
0
0
3
5
20
0
Person number 191
Statistics about locomotion anomalies in the day
Norm. jerk
Norm. sharp ang...
Norm. straightne...
Lapping
Pacing
4
3
2
1
0
3.2
2.7
0.1
0
3
Person number 191
Locomotion anomalies
Start time
End time
Duration (min)
Length
Number of pacings
Jerk
straightness
Normalized straightness
Number of sharp angles
Normalized of sharp angles
Normalized Jerk
Trajectory picture
10:39:13
10:59:10
20
505.8
3
64
73
0.1
54
2.7
3.2
show
1 - 1 / 1
Activity anomalies
Anomaly level of activities
Activity
Anomaly level
Explanation
Sweep the kitchen and dust the living room.
68.86%
The subject performed more than 2 Omissions, but less than 6 Omissions, and less than 2 Pacing.
Obtain a set of medicines and a weekly medicine dispenser, fill as per directions.
0.00%
The subject performed no Omissions, and no Pacing.
Write a birthday card, enclose a check and address an envelope.
0.00%
The subject performed no Omissions, and no Pacing.
1 - 8 / 8
Reach-touch subtle anomalies
Touched item
Activitiy
No data
Anticipation-omission overt anomalies
Activity
Previous task
Next task
Prepare a cup of soup using the microwave.
Participant pours water into cup of noodles
Participant boils water in microwave
Prepare a bowl of oatmeal on the stovetop from the directions given in task 12
Participant puts sugar in oatmeal
Participant puts oatmeal into pot:
1 - 3 / 3
Perseverations overt anomalies
Activity
Task
Number of repetitions
Wash and dry all kitchen countertop surfaces.
Participant wets the sponge
94
1 - 1 / 1
Action-additions overt anomalies
Task
Current Activity
Number of additions
No data
Ommisions overt anomalies
Activity
Missed task
Sweep the kitchen and dust the living room.
Participant retrieves dust pan and brush from closet
Sweep the kitchen and dust the living room.
Participant uses dust pan and brush
Sweep the kitchen and dust the living room.
Participants returns dust pan and brush to supply c...
Pick a complete outfit for an interview from...
Participant chooses correct outfit from closet:
1 - 5 / 5

Questionnaire for our user study.

| # | Measure | Statement |
|---|---|---|
| S1 | UTR | I have the feeling of trust in the system without explanations regarding its prediction of the overall cognitive status. |
| S2 | UTR | I have the feeling of trust in the system without explanations regarding its prediction of the anomaly level of activities. |
| S3 | HMTP | The system without explanations would help me providing a more accurate diagnosis than the one I would provide without the use of the tool. |
| S4 | HMTP | The system without explanations would help me completing the assessment in less time. |
| S5 | ES | Explanations are easily understandable. |
| S6 | ES | Explanations are detailed enough. |
| S7 | ES | Explanations are not lengthy. |
| S8 | ES | Explanations are useful to understand the reason for the system's prediction. |
| S9 | ES | Explanations are necessary to understand the reason for the system's prediction regarding the overall cognitive status |
| S10 | ES | Explanations are necessary to understand the reason for the system's prediction regarding the overall anomaly level of activities. |
| S11 | ES | Explanations help reducing the learning time on the system. |
| S12 | ES | In general, I am satisfied with the explanations provided by the system. |
| S13 | UTR | I have the feeling of trust in the system with explanations regarding its prediction of the overall cognitive status. |
| S14 | UTR | I have the feeling of trust in the system with explanations regarding its prediction about the anomaly level of activities. |
| S15 | HMTP | The system with explanations would help me providing a more accurate diagnosis than the one I would provide without the use of the tool. |
| S16 | HMTP | The system with explanations would help me completing the assessment in less time. |
| S17 | UTR | The explanations would help me deciding whether the prediction of the system is correct. |

# Framework--xAI

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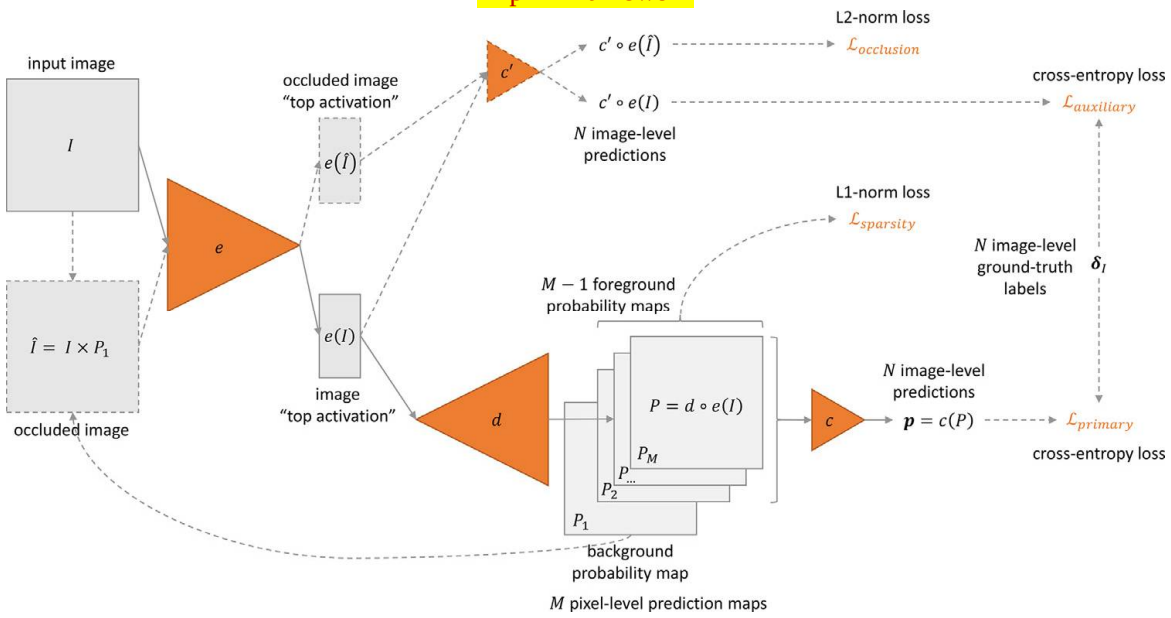
ExplAI framework



# Segmentation

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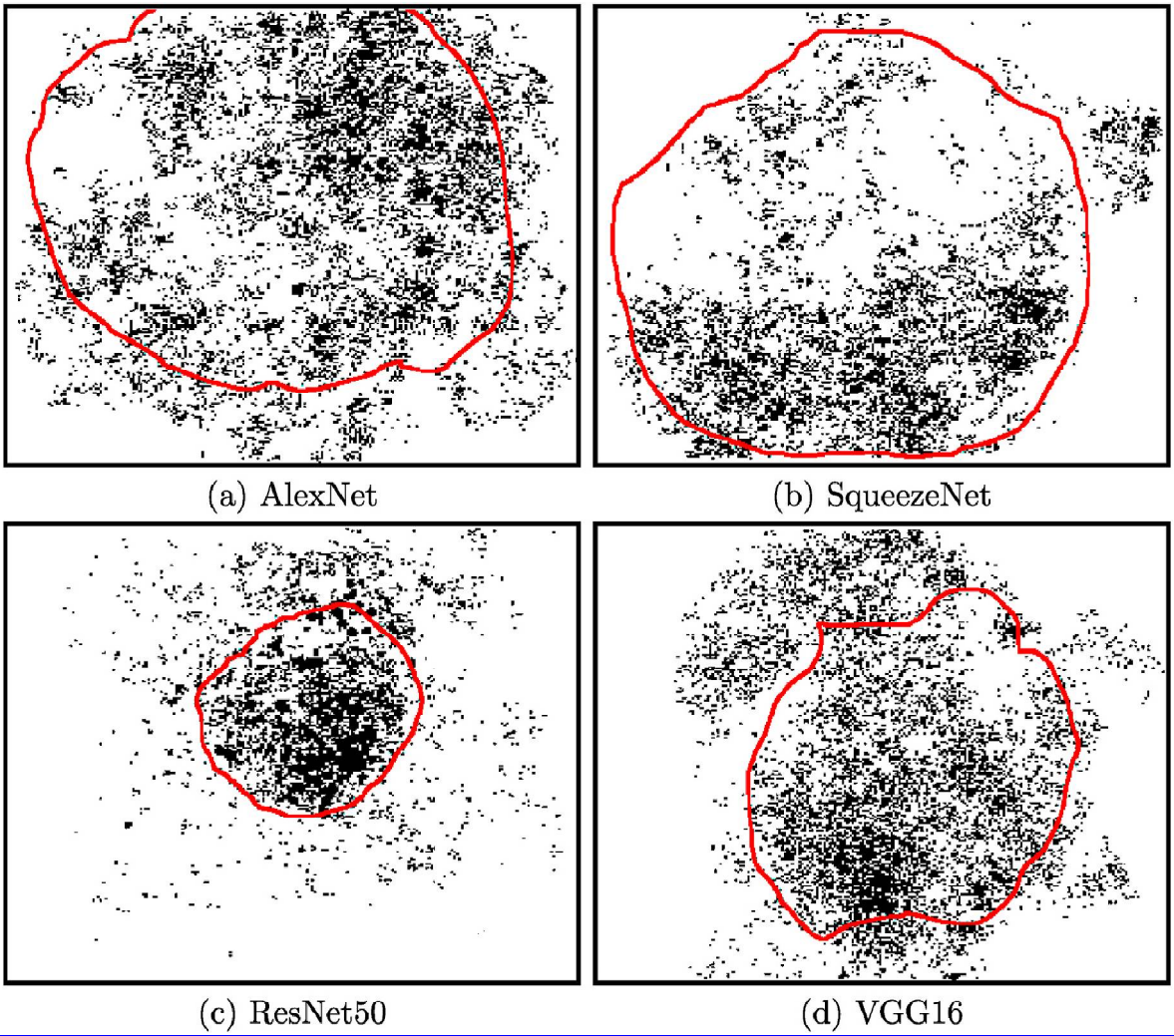
Computational segmentation



(a) AlexNet (b) SqueezeNet

(c) ResNet50 (d) VGG16

- TP samples (black)
- ground truth delineated area (red) over (a) AlexNet, (b) SqueezeNet, (c) ResNet50, (d) VGG
- Every segmented sample is related to the best XAI interpretation technique obtained for the respective CNN architecture

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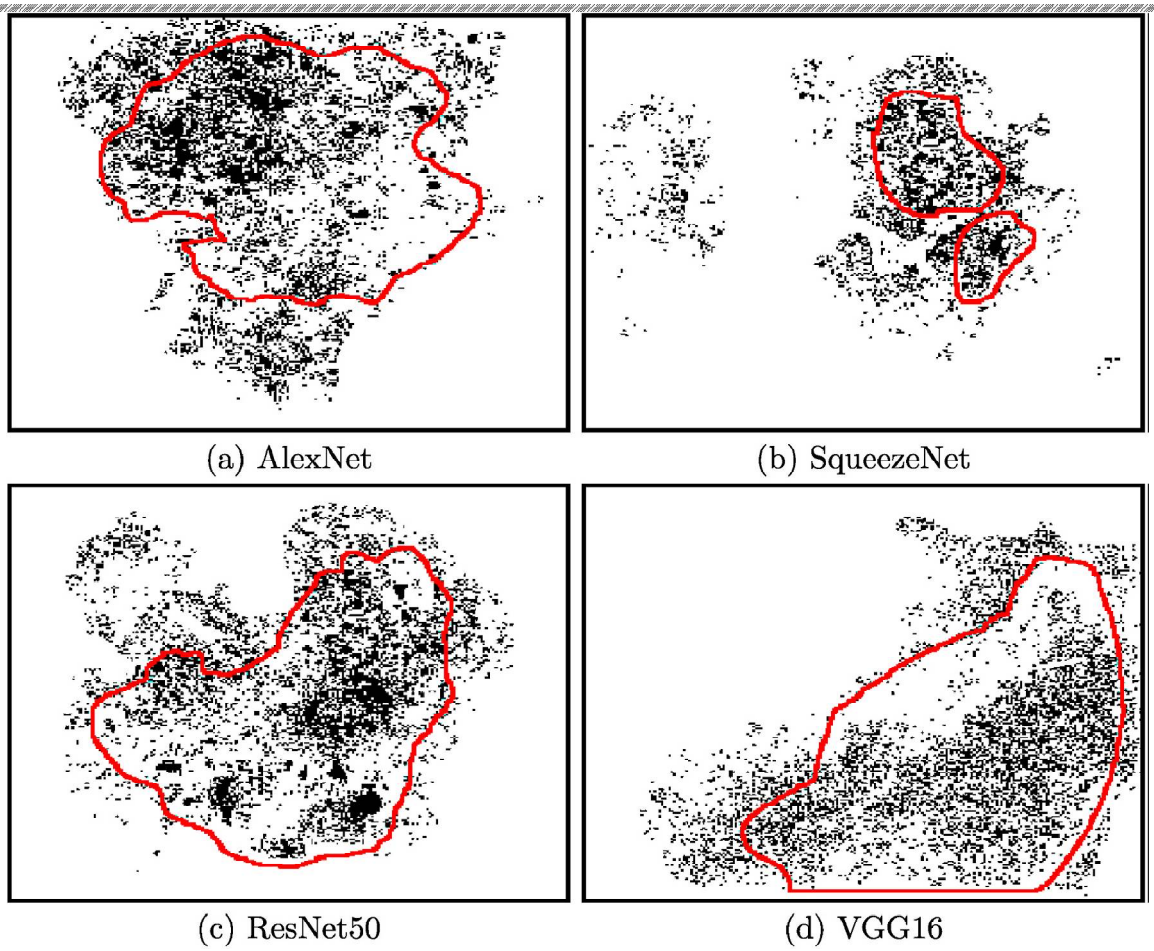
MICCAI dataset

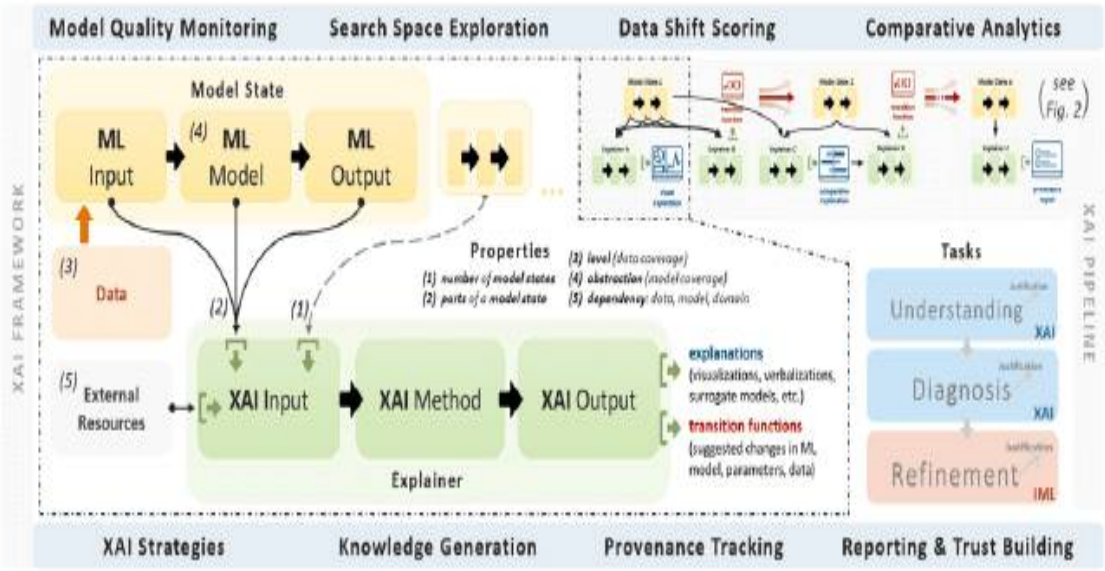



- MICCAI samples (black)
- Ground truth delineated area (red) over (a) AlexNet, (b) SqueezeNet, (c) ResNet50, (d) VGG
- Every segmented sample is related to the best XAI interpretation technique obtained for the respective CNN architecture

***Explainability***
***Interpretability***
***xAI.Med***

113

Expl(Figures-information-rules-scripts-Tables)
(xFirst)←xAI_tools(OPIUM(Data))




- ✓ OPIUM : Operators Input oUtput Model;
- ✓ Operators: [Numeric, Logical, Algebraic, symbolic}
- ✓ Data : {Numeric, Images, Literal, Boolean}

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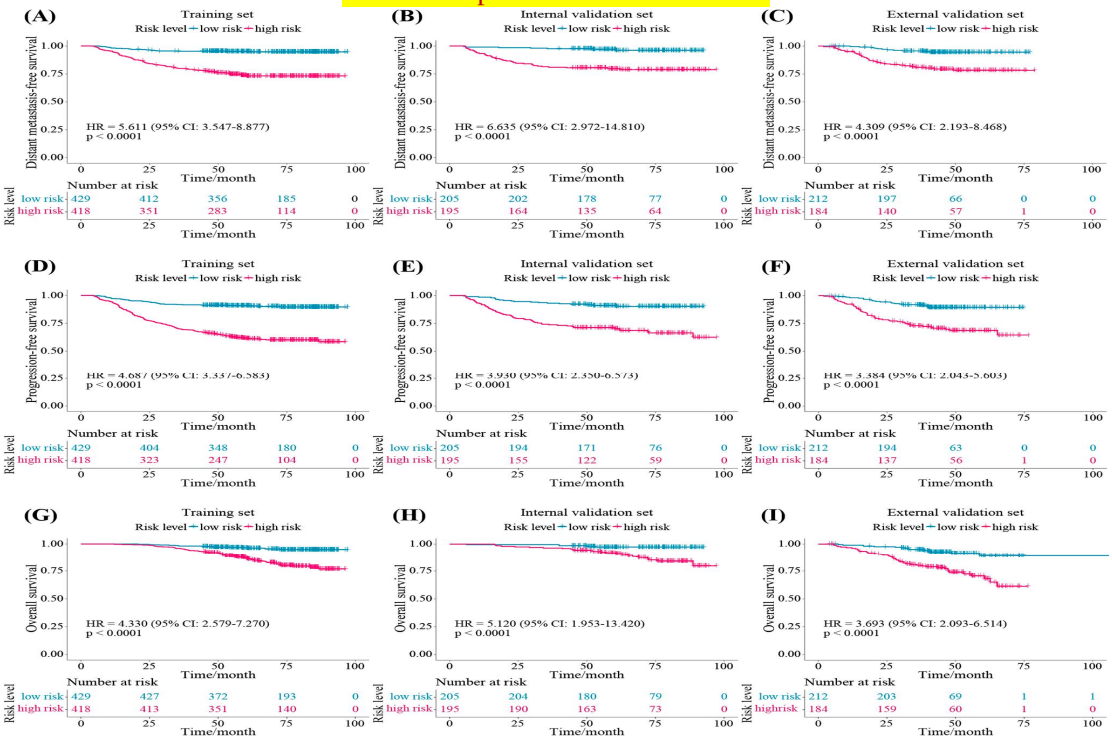
Variable importance-- model XGB-C




- ✓ Tv, volume of the primary tumor;

- ✓ Ta, maximum cross-sectional area of the primary tumor;
- ✓ Ld, vertical dimension of the reginal lymph nodes;
- ✓ LDH, lactate dehydrogenase;
- ✓ Lv, volume of the reginal lymph nodes;
- ✓ La, maximum cross-sectional area of the reginal lymph nodes;
- ✓ Td, vertical dimension of the primary tumor;
- ✓ EBV DNA, Epstein-Barr virus DNA;
- ✓ BMI, body mass index.

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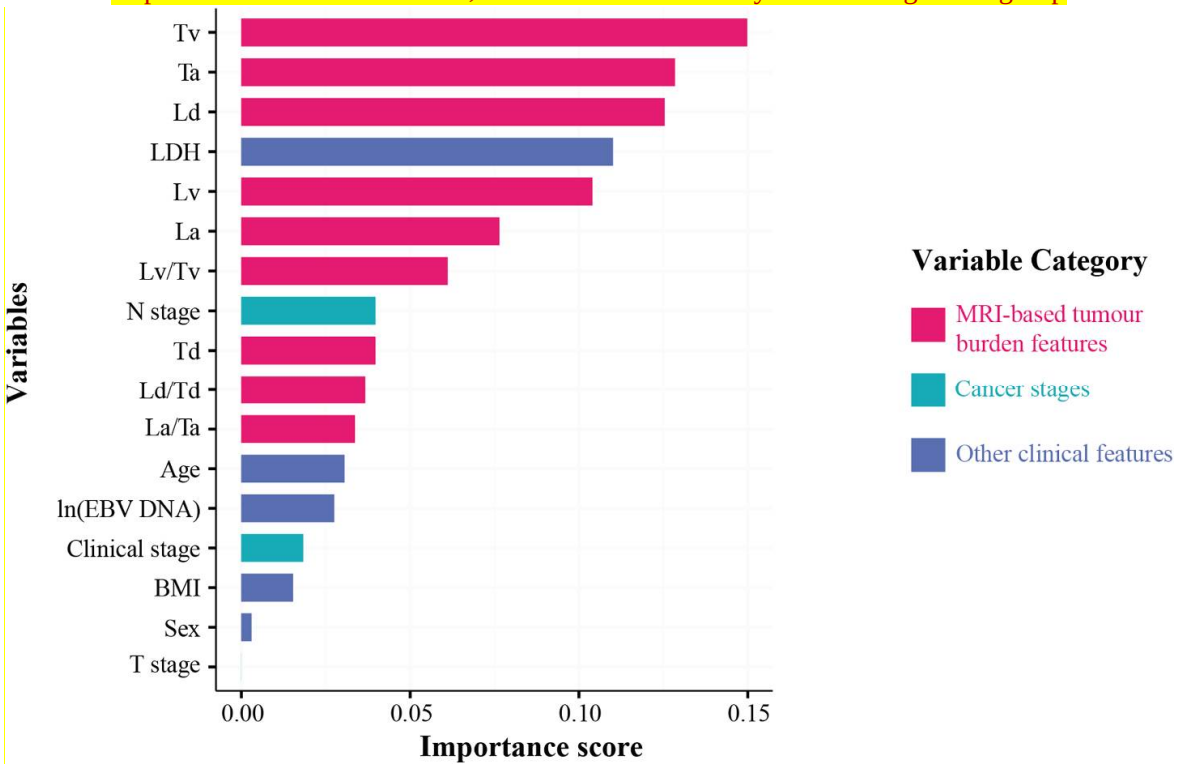
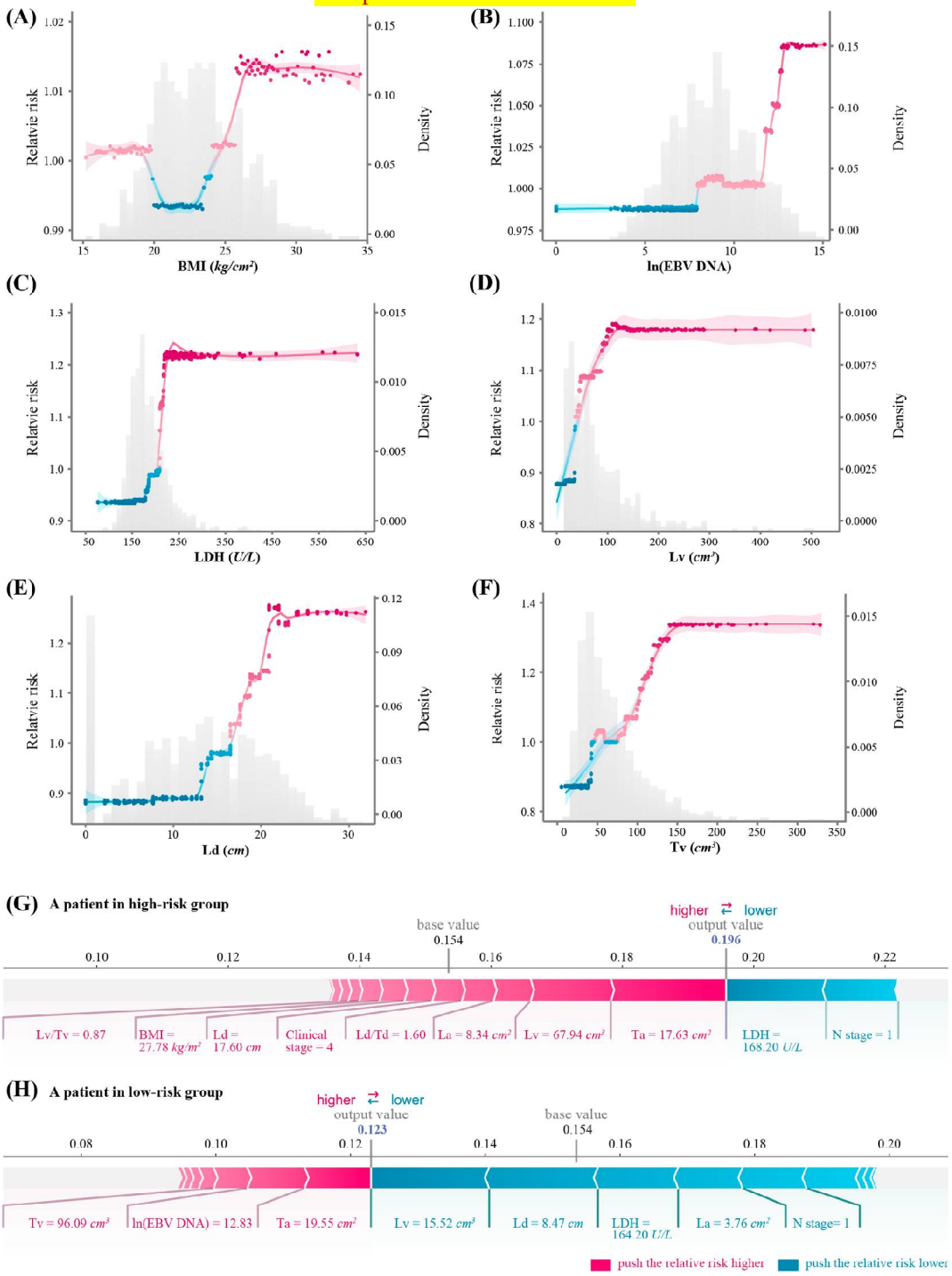
Kaplan-Meier curves of DMFS, PFS and OS stratified by low- and high- risk group



Interpretation of model XGB-C



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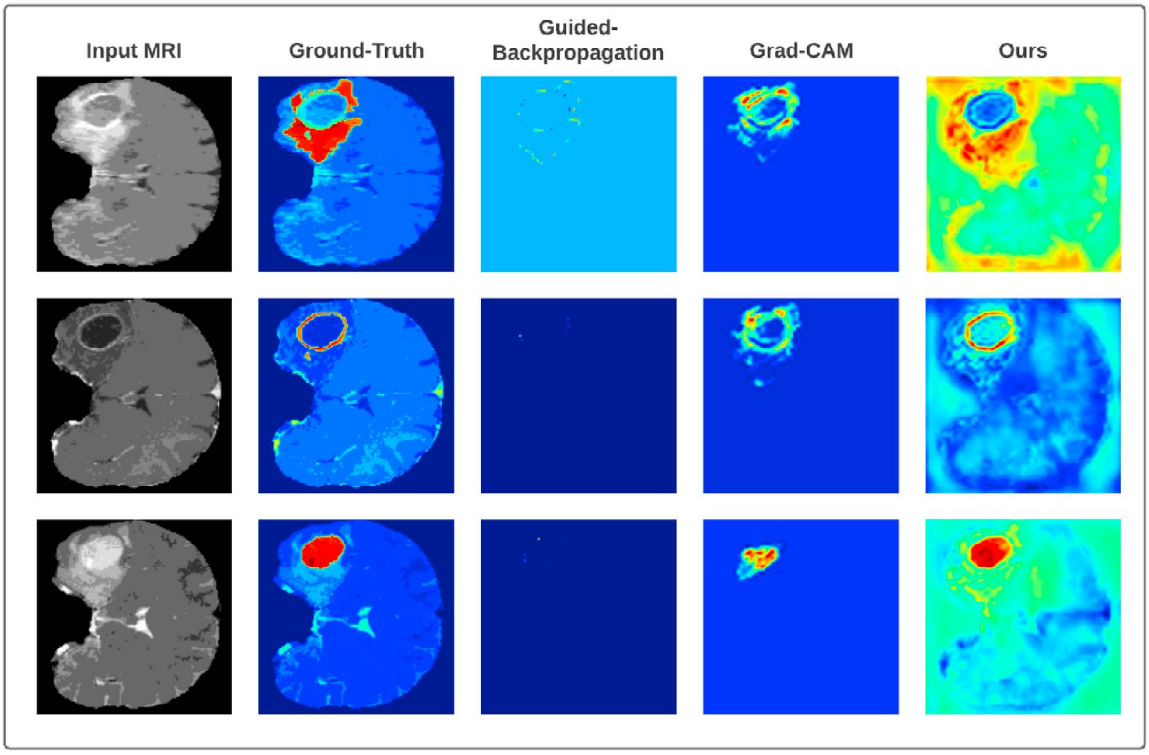
|---|---|---|

Visual explanations from

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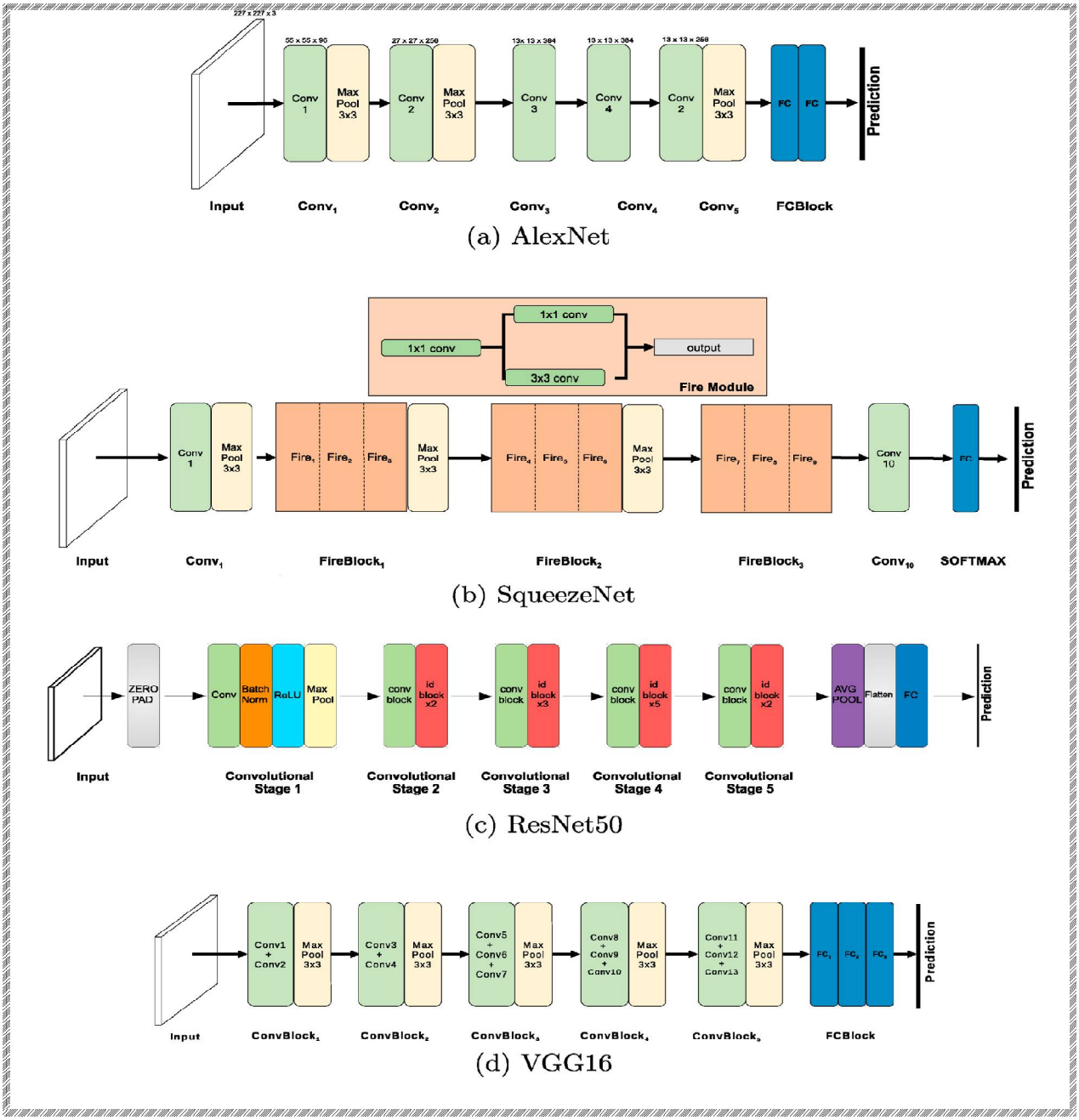
|---|---|---|

Prediction interpretation

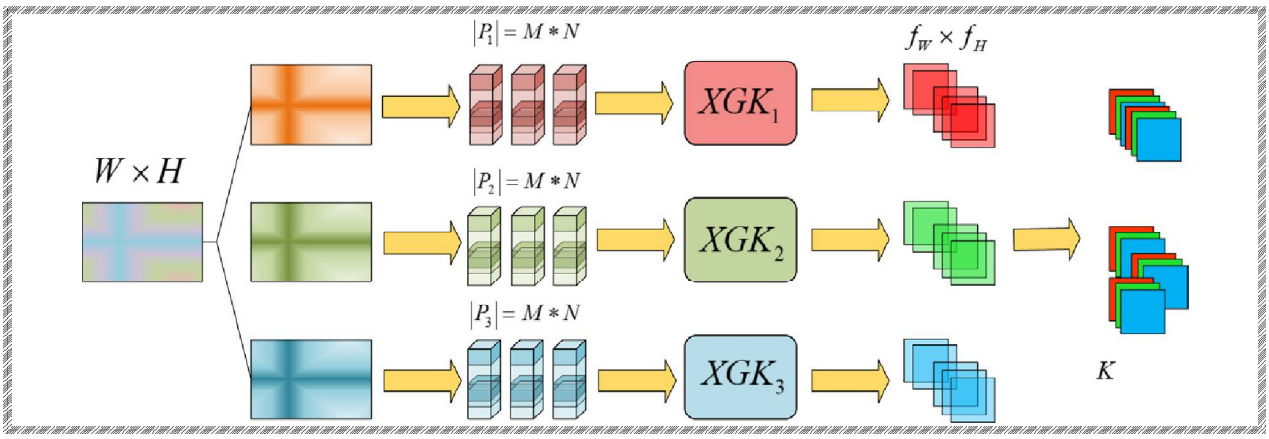



(a) AlexNet

(b) SqueezeNet

(c) ResNet50

(d) VGG16

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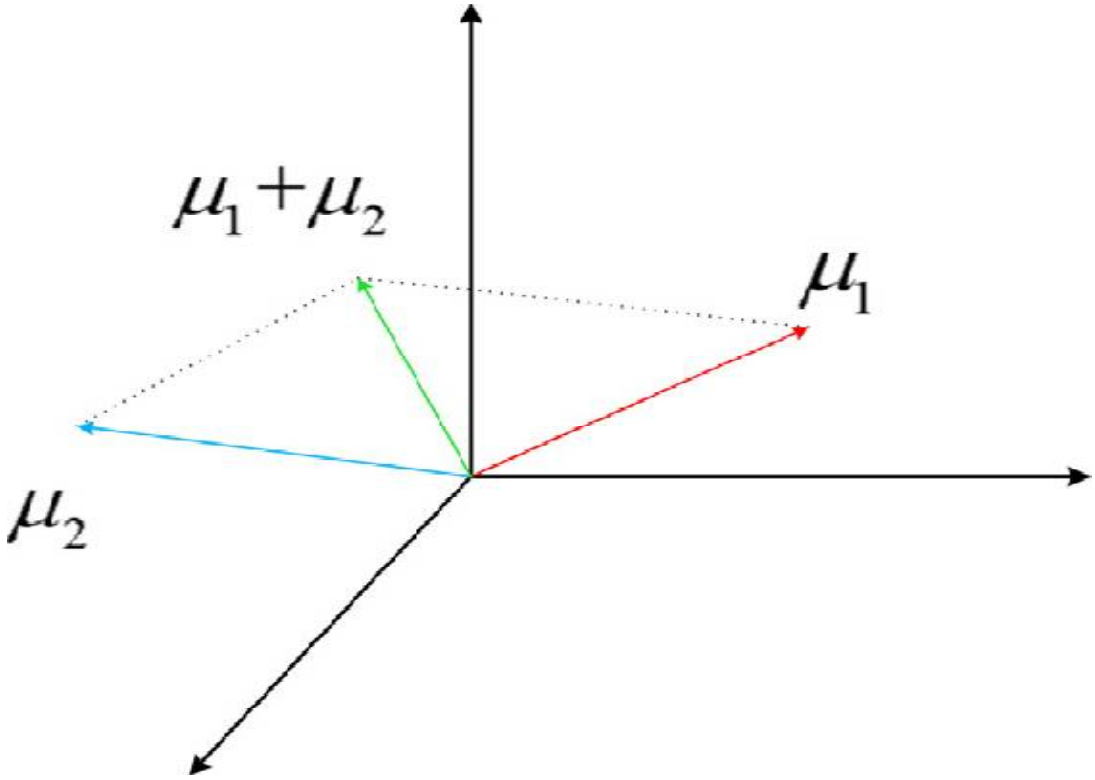
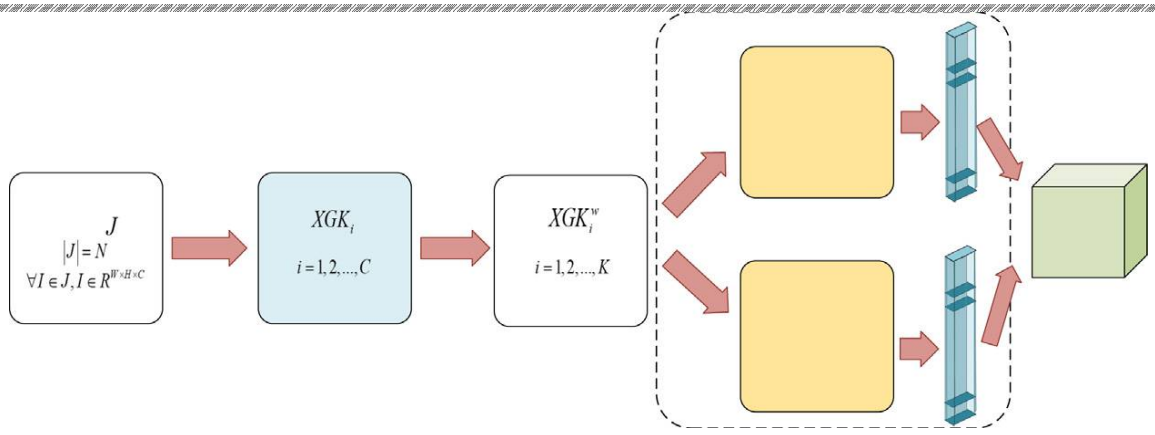
|---|---|---|

two kernels cancel each other out

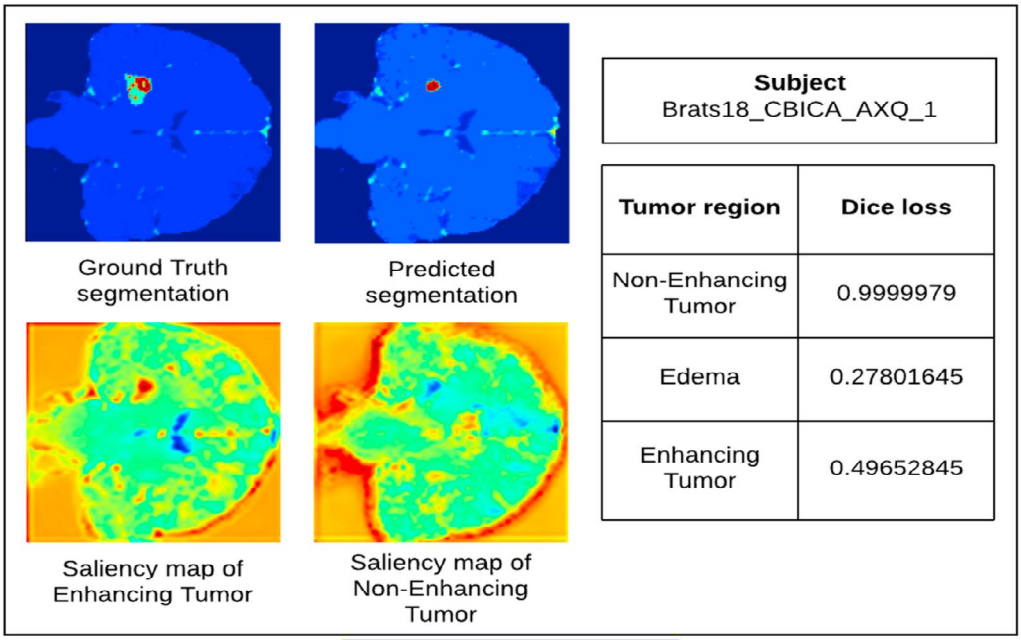



| xAI.Med. | | 2021-14 |
|---|---|---|

Explainable ensemble Gaussian kernel model





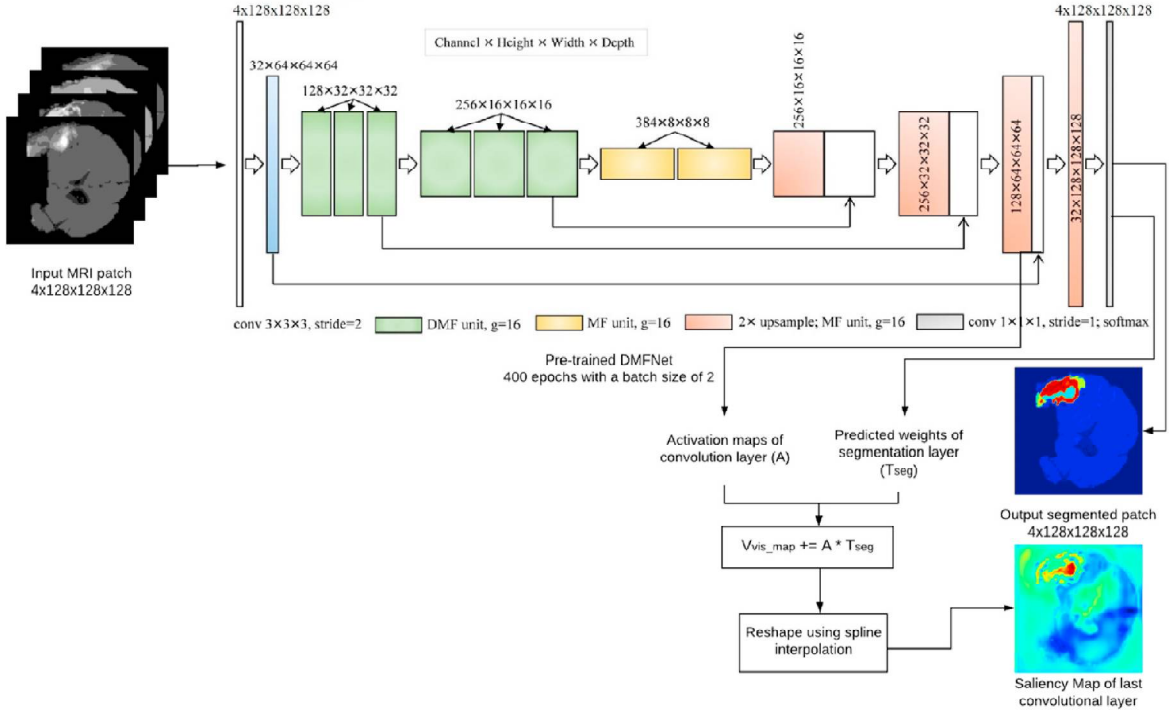




Failure modes of the network

- ✓ Ground Truth and Prediction images ---- Red: enhancing tumor ; sea green: non-enhancing tumor
- ✓ saliency maps ---- Red represents high attention; Blue low attention;



Interpretability pipeline




Brain tumor segmentation model

# Pixel level. xAI

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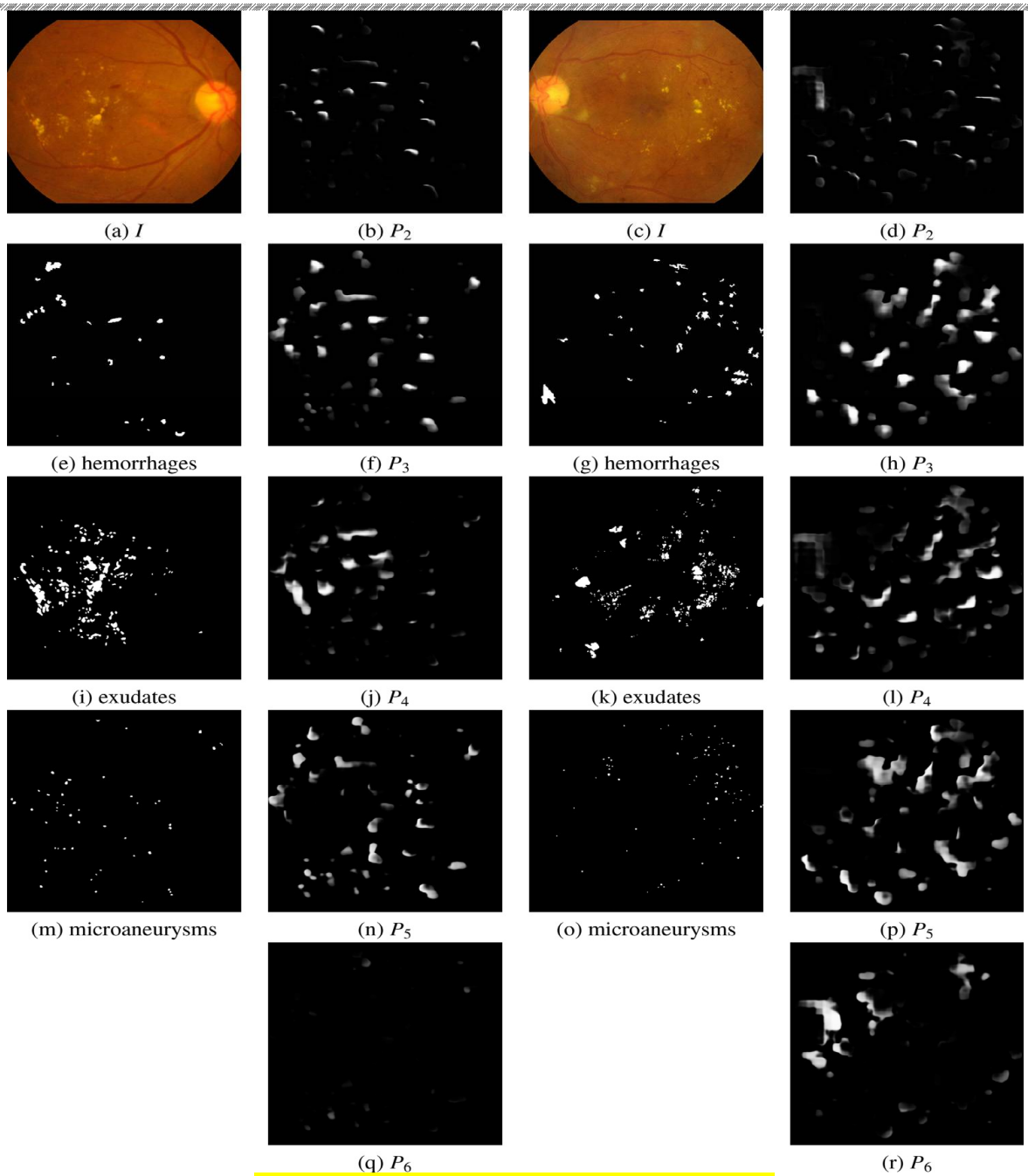
|---|---|---|

. Pixel-level predictions for images




EfficientNet-B5 backbone; M = 6 pixel-level labels

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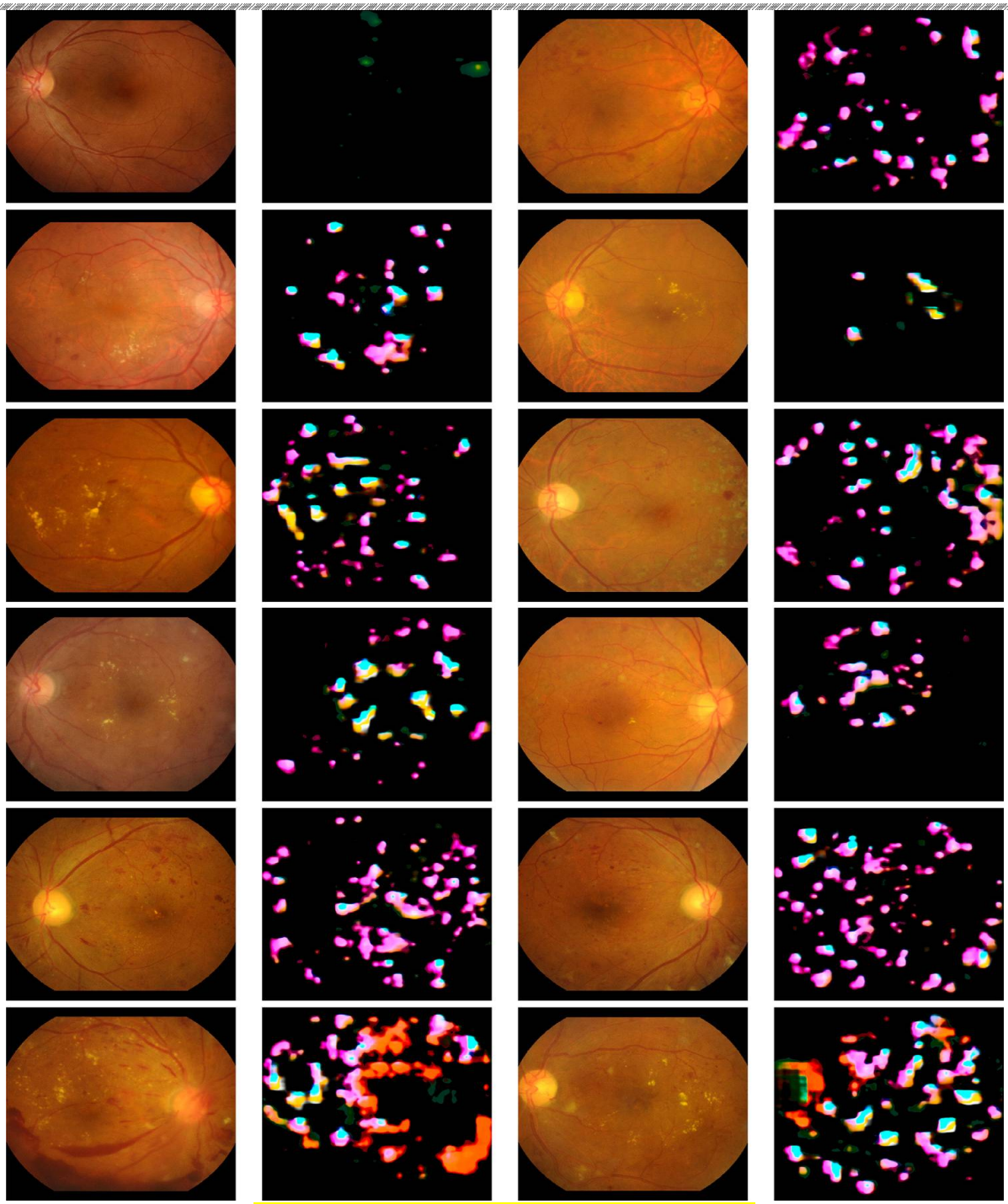
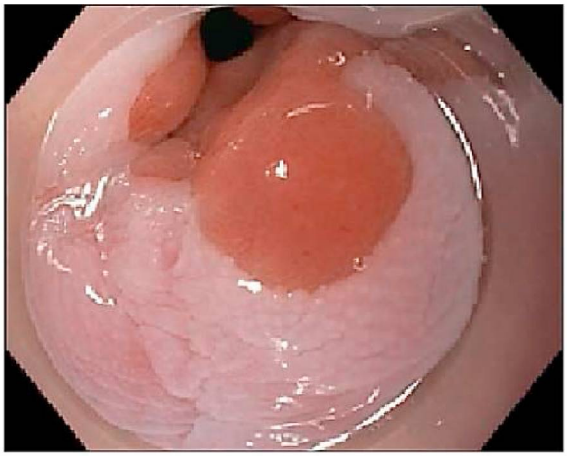
|---|---|---|

Color-coded pixel-level predictions for images

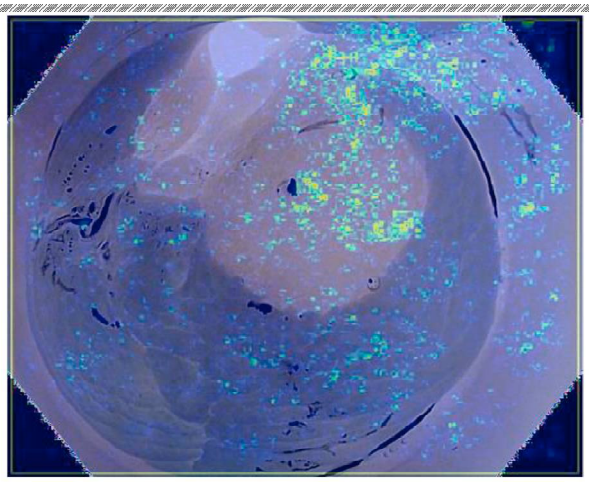


EfficientNet-B5 backbone;  M = 6 pixel-level labels

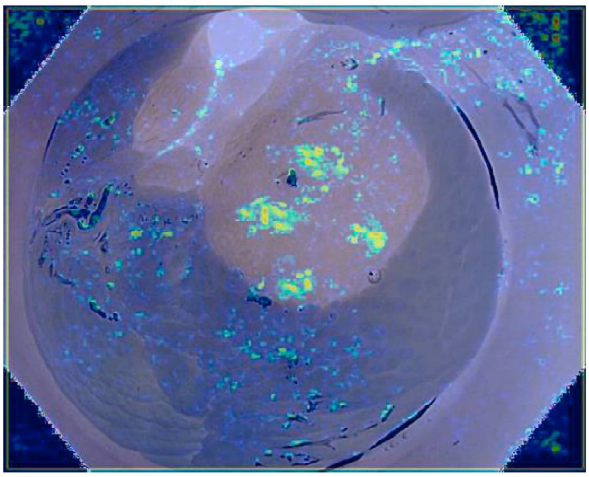
| xAI.Med. | | 2021-13 |
|---|---|---|
| Explainable AI heatmaps | | |



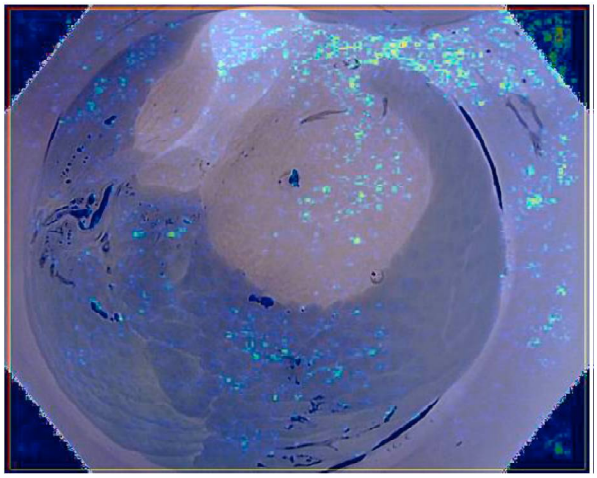
(a) Original Image



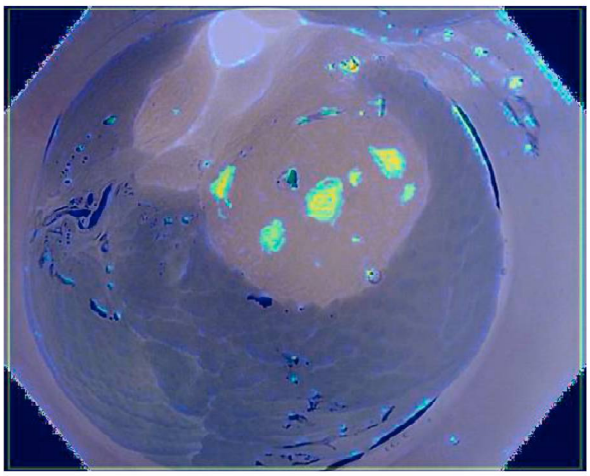
(b) Saliency



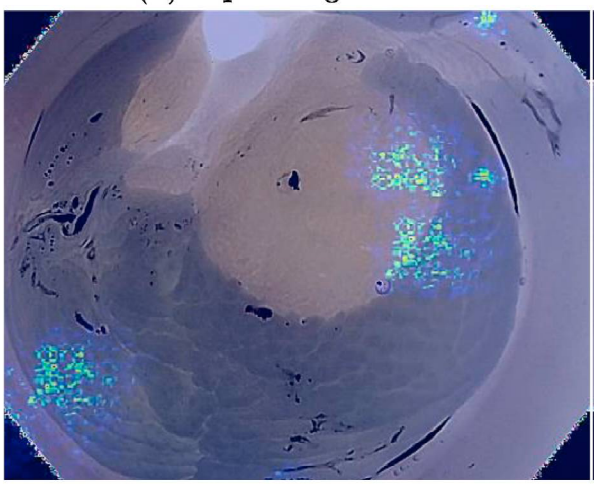
(c) Integrated gradients



(d) Input × gradients



(e) Guided backpropagation



(f) DeepLIFT

- Colors of attributes range from blue (not discriminative) to white-green (discriminative)
- Related to their impact on the target's class prediction