Interleaving machine learning with reasoning

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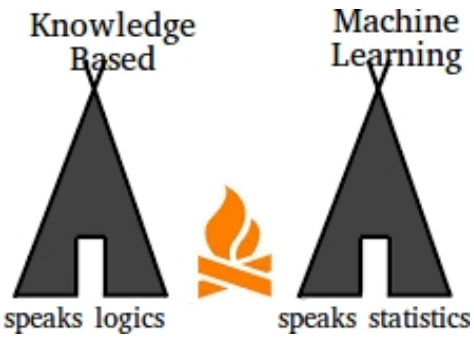

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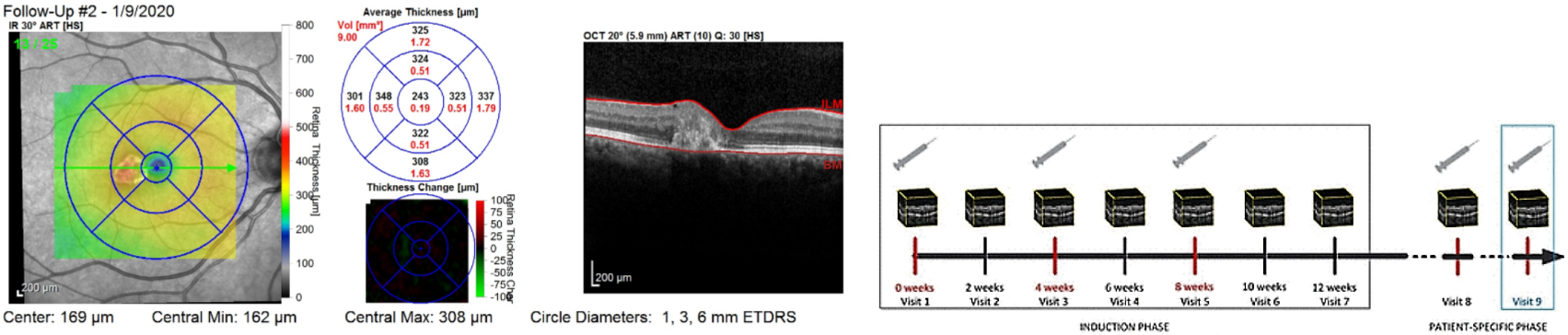
Running project (2022-2024)

New OCT Biomarkers Identified with Deep Learning for Risk Stratification of Patients with Age-related Macular Degeneration, PED616,

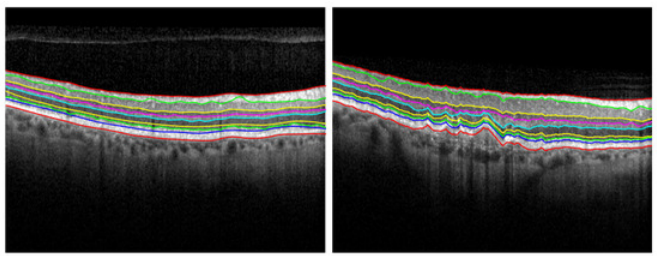
1. Predicting disease evolution or visual acuity from small-time series



Center: 169 µm Central Min: 162 µm Central Max: 308 µm Circle Diameters: 1, 3, 6 mm ETDRS

How to learn from small-sized time series? How to handle different time intervals between visits? How to learn from different numbers of visits (1–5)?

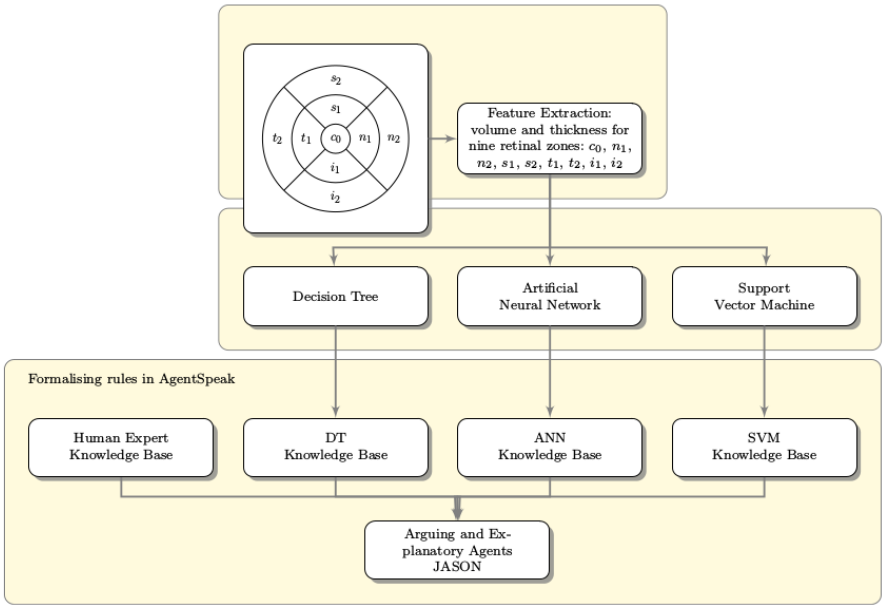
2. Segmenting retinal layer: Human in the loop, not ML approach



3. Building a support tool for ophthalmologists

- explain algorithmic decisions to humans (e.g. by extracting rules from models)
- include the ophthalmologist in the loop (by including expert knowledge)
- build safety cases (by creating assurance argument patterns in GSN)

Argue on Classifications of Retinal Conditions

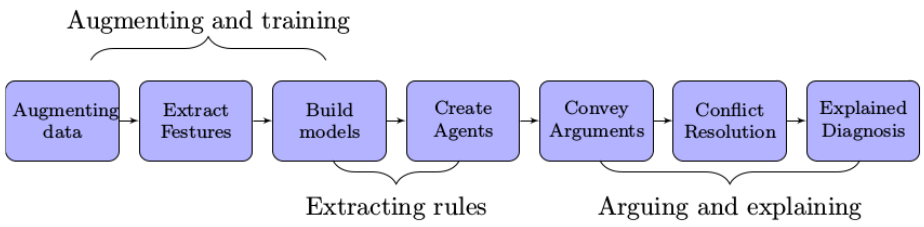


$R_1^{DT(a=.97)}$: $t(s_1) \leq .35 \wedge v(s_1) \leq .51 \rightarrow^{69} \langle 1, 0, 0 \rangle$

$R_2^{SVM(a=.7)}$: $t(n_2) \leq .45 \wedge t(t_2) > .41 \wedge v(n_2) < 2.41 \wedge v($
$1.94) \rightarrow \langle .0149, .5373, .4478 \rangle$

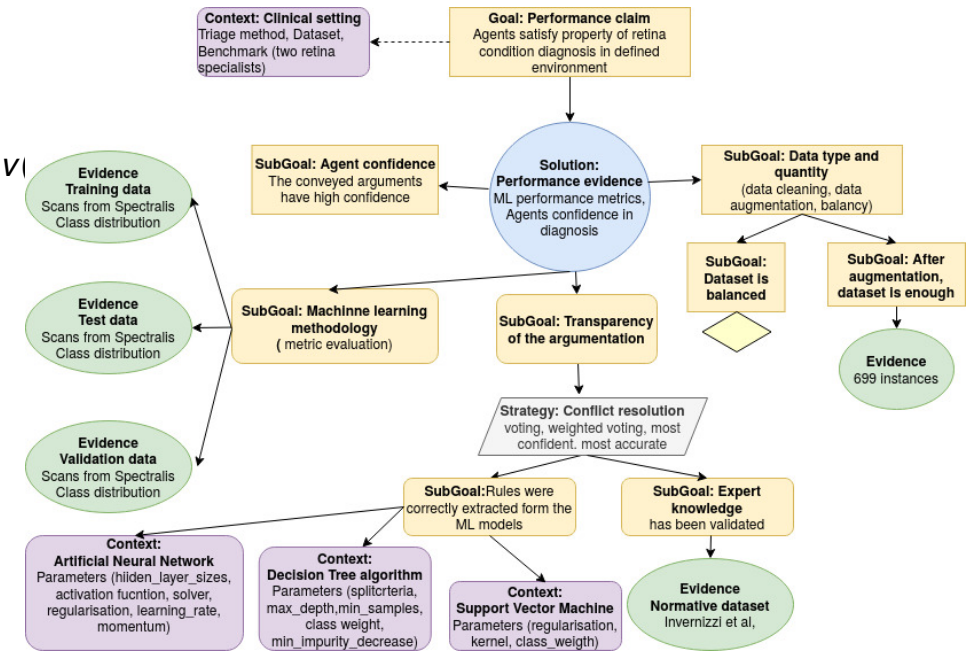
$R_1^{ANN(a=.75)}$: $v(t_2) \leq 1.28 \rightarrow \langle .0045, .0856, .9099 \rangle$

R_1^{E}: $t(c_0) = 280.1 \pm 17.5 \rightarrow^{200} \langle 0, 0, 1 \rangle$

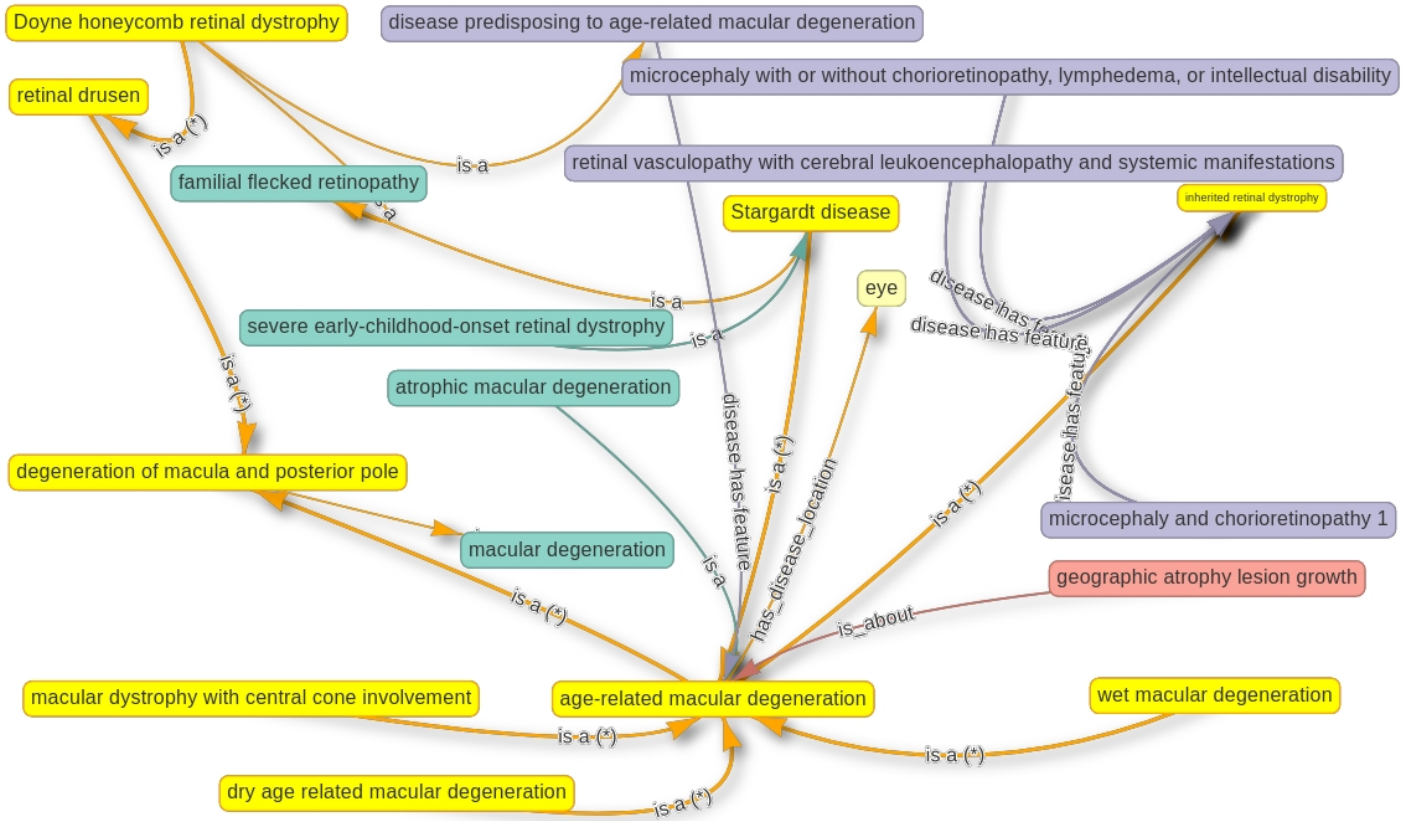


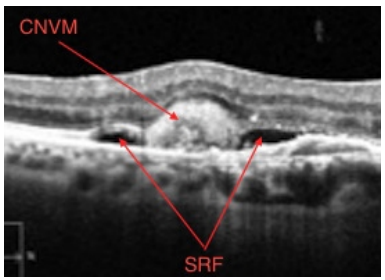
Generating explanations in NL

[Master]	Suggested diagnosis is *Diabetic Retinopathy*
	Agent *DT* is 100% sure, and *DT*'s accuracy is 0.96
	Agent *SVM* is 97% sure, and *SVM*'s accuracy is 0.75
	Agent *ANN* is 95.79% sure, and *ANN*'s accuracy is 0.95
	Agent *E* had no arguments
[Master]	Diagnosis *Diabetic Retinopathy* was chosen because:
	The thickness value in t_1 zone is smaller than 0.34 and
	The thickness value in t_2 zone is smaller than 0.3 and
	The thickness value in s_2 zone is greater than 0.3 and
	The volume value in s_1 zone is smaller than 0.58 and
	The thickness value in s_1 zone is greater than 0.35.



5. AI for personalized ophthalmology residency training : Deep learning gives a presumptive diagnosis and assess case difficult, Expert sytems allocates cases
6. Describing OCT biomarkers in Description Logics





$$f_3 : hasDisease.WetAMD \quad (1)$$

$$f_3 : \exists hasBM.(Type2CNVM \sqcap isAbove.RPE \sqcap \exists hasAdjacentBM.SRF \sqcap \forall hasAdjacentBM.SRF \quad (2)$$

$$f_3 : \exists hasBM.(Exudate \sqcap isLocated.Nasal) \quad (3)$$

$$Type1CNVM \sqsubseteq CNVM \sqcap \exists isBeneath.RPE \sqcap \quad (4)$$

$$\exists bv : appear.(Fibrovascular \sqcup HemorrhagicPigmentEpithelialDetachment \quad (5)$$

$$Type2CNVM \sqsubseteq CNVM \sqcap \exists isAbove.RPE \exists hasAdjacentBM.SRF \quad (6)$$

Fact checking with explanations

Myth
5G mobile networks spread Covid-19
Exposing yourself to temperatures higher than 25C prevents COVID
Antibiotics are effective in preventing and treating the new coronavirus
The new coronavirus can be transmitted through mosquito

Generating counterspeech

```
The input text contradicts our trusted sources
The ontology is incoherent: Retrovirus is unsatisfiable
Explanation #1:
    knowledge from input text:
Every Retrovirus is killed by Amoxicillin.
    knowledge from trusted sources (counterspeech):
Amoxicillin is an Antibiotic. (https://wordnet.princeton.edu/)
Every Retrovirus is a Virus. (https://wordnet.princeton.edu/)
Everything that is killed by an Antibiotic is a Bacterium. (https://www.who.
    ↪ int/emergencies/diseases/novel-coronavirus-2019/advice-for-
    ↪ public/myth-busters#antibiotics)
No Virus is a Bacterium. (https://www.healthdirect.gov.au/bacterial-vs-viral
    ↪ -infection)

Some part of the input is entailed by our trusted sources:
Entailed information #1: No Bacterium is a Virus.
Explanation #1: No Virus is a Bacterium. (https://www.healthdirect.gov.au/
    ↪ bacterial-vs-viral-infection)
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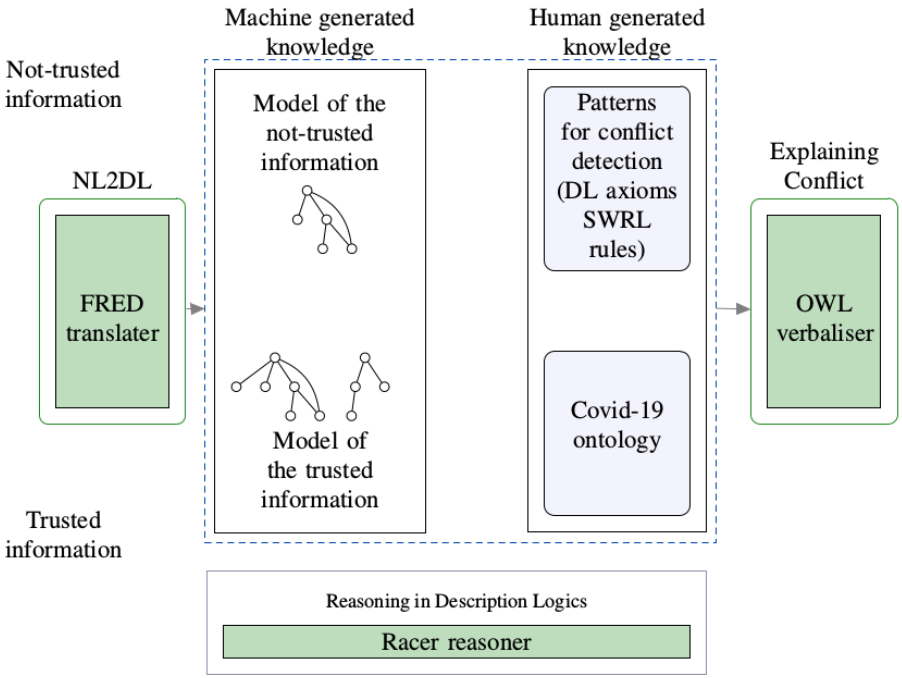
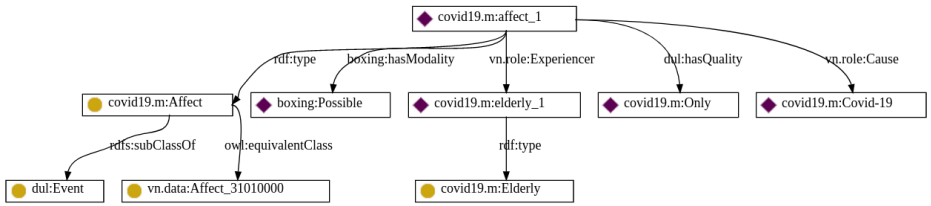
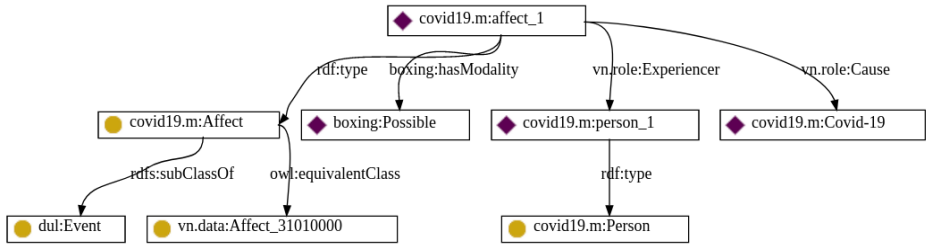


Step 1: “Covid-19 can affect elderly only“



Step 2: “Covid-19 can affect anyone”



ISI articles (since 2021)

1. Groza A, Toderean L, Muntean G. A., Nicoara D. Agents that argue and explain classifications of retinal conditions. Journal of Medical and Biological Engineering. 2021 Oct;41(5):730-41
2. Marginean B. A., Groza A., Muntean G., Nicoara S.D. Predicting Visual Acuity in Patients Treated for AMD. Diagnostics. 2022 Jun 20;12(6):1504
3. Bilc, S.; Groza, A.; Muntean, G.; Nicoara, S.D. Interleaving Automatic Segmentation and Expert Opinion for Retinal Conditions. Diagnostics 2022, 12, 22.
4. Cheres. I., Groza., A "The Profile": unleashing your deepfake self, Multimedia Tools and Applications, In press, 2023
5. Muntean G. A., Groza A., Marginean A., Steiu M., Muntean V., Nicoara S. D. Artificial intelligence for personalized ophthalmology residency training, J. of Clinical Medicine.
6. Marginean A. N., Muntean D. D., Muntean G. A., Priscu A., Groza A., et al. Reliable Learning with PDE-Based CNNs and DenseNets for Detecting COVID-19, Pneumonia, and Tuberculosis from Chest X-Ray Images. Mathematics. 2021; 9(4)

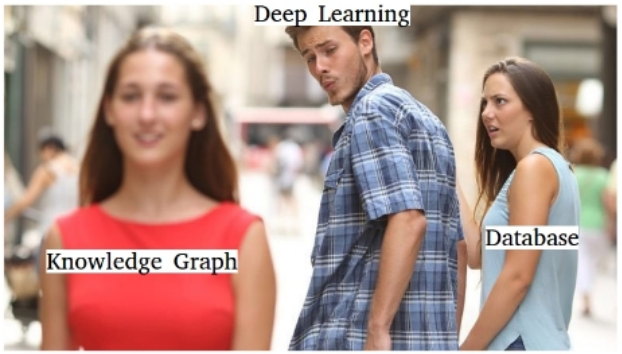
1. Machine Learning

We know how to torture data to make a full confession

We master various torture instruments: CNN, RNN, GNN, SVM, PCA, Gradient Boosting Trees

2. Knowledge Graphs

We know how to interleave deep learning with knowledge graphs



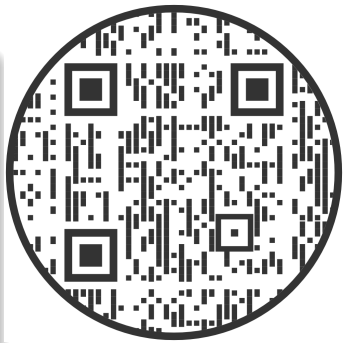
We know how to build domain ontologies

Direction towards Neuro-symbolic integration

- Integrating domain-specific knowledge in the learning process
- XAI - assessing explanations and using explanations for debugging
- Verified and trustable AI
- Minimise time-to-market by facilitating technical audits
- Natural language understating: learning meaning

Supporting AI applied by developing in the institute

- Reading center - in the context of EU Data Spaces
- Certification center - in the context of AI Act
- Regulatory sandbox - in the context of AI Act



$$\forall x \; participates(x, thisSession) \rightarrow thank(I, x)$$

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