



AI Applications in Healthcare and Possible Future Approaches to Enhance Decision Transparency

Florin Leon

Department of Computers

Faculty of Automatic Control and Computer Engineering

“Gheorghe Asachi” Technical University of Iași, Romania



AI Applications in Healthcare

- Ophthalmology
 - Studying glaucoma progression and suggesting a possible treatment
- Rheumatology
 - Analyzing tuberculosis reactivation in patients with rheumatoid arthritis and ankylosing spondylitis
- Oncology
 - Investigating Claudin-7 expression levels in advanced colorectal cancer



Ophthalmology

- Studying glaucoma progression and suggesting a possible treatment
 - Târcoveanu, F., Leon, F., Curteanu, S., Chiseliță, D., Bogdănici, C. M., Anton, N. (2022). *Classification Algorithms Used in Predicting Glaucoma Progression*. Healthcare. <https://doi.org/10.3390/healthcare10101831>



Glaucoma Progression and Treatment

- Glaucoma is the second leading cause of irreversible blindness and is dangerous especially for aging people
- It has an asymptomatic progression, and thus early detection is crucial, but current diagnostic methods are resource-intensive and require repeated testing
- Risk factors for glaucoma include elevated intraocular pressure, advanced age, ethnicity, family history, and optic disc characteristics
- AI tools can extract key information from the datasets and aid in screening, diagnosis, and prognosis assessment

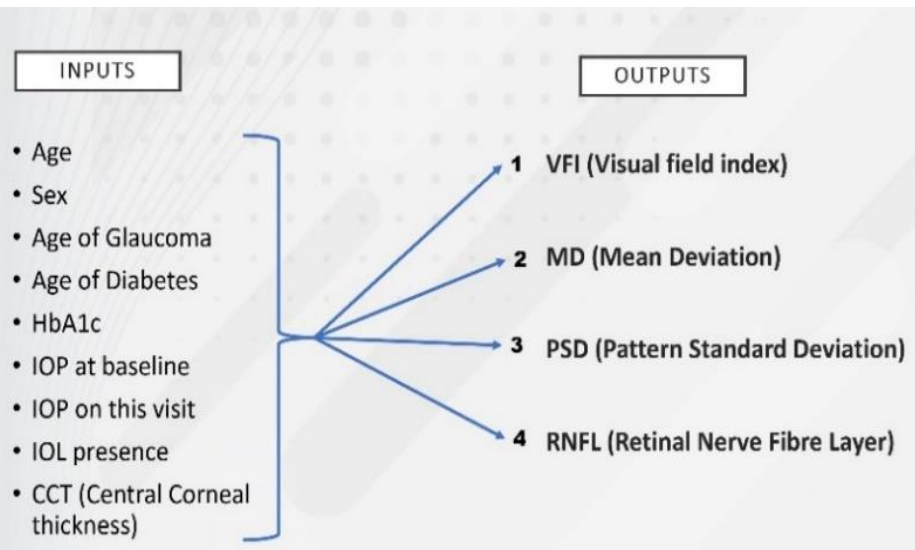


Data Collection

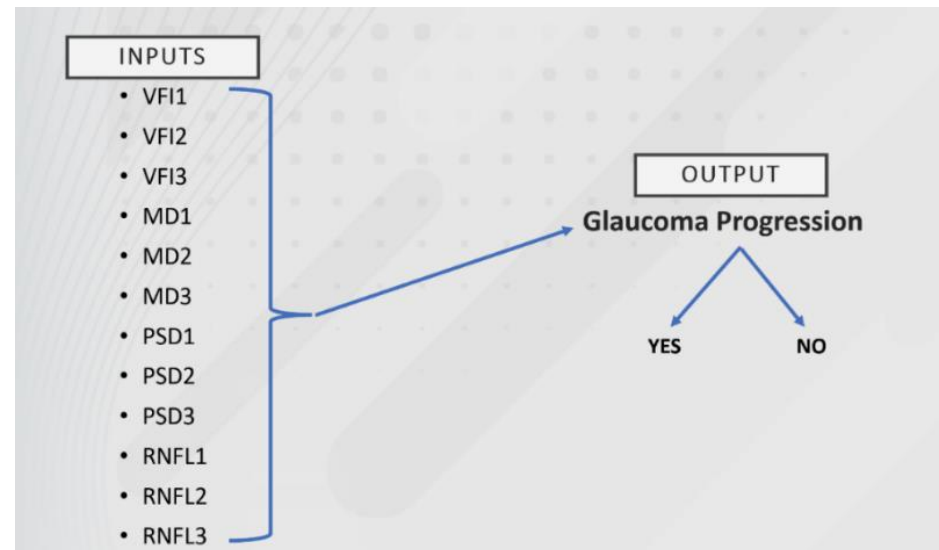
- Data from the Countess of Chester Hospital (UK) and St. Spiridon Hospital in Iași (Romania)
- The dataset was based on various investigations such as visual field assessments, optical coherence tomography (OCT) scans, intraocular pressure (IOP) measurements, visual acuity assessments, and diabetic parameters
- The study focused on patients with primary open-angle glaucoma or ocular hypertension, with or without diabetes, undergoing at least three follow-up visits
- Machine learning techniques were used to enhance understanding and prediction of disease evolution

Dataset Structure

Initial data: 50 patients in Chester, both eyes, 3 control visits, 47 attributes;
52 patients in Iași



Inputs and outputs considered in four problems created to predict some risk factors in glaucoma evolution



Selected inputs for predicting glaucoma progression for a consolidated dataset

Some Results

Results of classification algorithms to predict the VFI parameter based on glaucoma risk factors

Algorithm	Training	Cross-Validation
SVM (PUK kernel, $C = 100$)	0.9990	0.7963
kNN ($k = 1, w_i = 1/d_i$)	0.9999	0.7168
Random Forest ($n = 100$)	0.9839	0.8558
C4.5 (unpruned)	0.8905	0.7279
NNGE	0.9558	0.6931

The weights for each input in relation to the VFI output calculated with the NNGE algorithm

Inputs	Weights
Age	0.109
Sex	0.055
Glaucoma age	0.111
Diabetes age	0.088
HbA1c	0.066
Baseline IOP	0.150
IOP on this visit	0.072
IOL presence	0.0006
CCT	0.089

Results obtained with different classification algorithms for assessing the need for alteration of glaucoma treatment

Algorithm	Correctly Classified Instances	Incorrectly Classified Instances	Kappa Statistic	Mean Absolute Error	Root Mean Squared Error
Random Tree	65	35	0.2757	0.35	0.5916
Random Forest	84	16	0.6497	0.2742	0.3541
C4.5	79	21	0.5329	0.2353	0.4285
NNGE	83	17	0.6298	0.17	0.4123
kNN	80	20	0.5379	0.2065	0.4425
MLP	86	14	0.7029	0.1436	0.3445
SVM	62	38	0	0.38	0.6164
AdaBoost	85	15	0.6664	0.2312	0.361



Rheumatology

- Analyzing tuberculosis reactivation in patients with rheumatoid arthritis and ankylosing spondylitis
 - Mircea-Vicoveanu, A.M., Rezuş, E., Leon, F., Curteanu, S. (2021). *Analyzing Tuberculosis Reactivation in Patients with Rheumatoid Arthritis and Ankylosing Spondylitis Treated with Biological Therapy Using Machine Learning Methods*. Applied Sciences. <https://doi.org/10.3390/app112311400>



Managing Tuberculosis Risk

- Biological therapy for rheumatoid arthritis (RA) and ankylosing spondylitis (AS) targets specific inflammatory molecules; it is used when traditional treatments fail
- Patients undergoing biological therapy face an elevated risk of developing tuberculosis (TB)
- Diagnosing latent TB infections involves assessing medical history and conducting interferon-gamma release assays such as the QuantiFERON-TB Gold test
- Machine learning algorithms can be used to identify high-risk patients



Dataset Structure

- 76 patients diagnosed with RA and 63 patients with AS (Rheumatology Clinic I of the Rehabilitation Hospital in Iași)
- Inputs
 - Age (integer, years)
 - Gender (binary)
 - Biological therapy (symbolic)
 - Difference from the beginning of therapy (integer, days)
 - The use of remissive therapy or corticosteroid therapy (binary)
 - The presence of a history of tuberculosis (binary)
- Output
 - QuantiFERON TB Gold Test indicator (binary) - *unbalanced*



Some Results

Classification results for all records in the dataset

Classification Method	Accuracy on the Training Set	Accuracy for Cross-Validation
Random forest 100 trees	100%	80%
Random forest 1000 trees	100%	81.7391%
NN	100%	80%
kNN k = 20, w = 1/d	100%	84.3478%
kNN k = 100, w = 1/d	100%	81.7391%
C4.5 pruned	80%	80%
C4.5 pnpruned	92.1739%	77.3913%
SVM Puk kernel	85.2174%	78.2609%

- Data augmentation
 - Decreasing FP rate from ~ 0.75 to ~ 0.18
- Classification of subsets
 - RA, AS
- Explicit results
 - Decision trees



Oncology

- Investigating Claudin-7 expression levels in advanced colorectal cancer
 - Ianole, V., Danciu, M., Volovăț, C., Ștefănescu, C., Herghelegiu, P.C., Leon, F., Iftene, A., Cusmuluc, C.G., Toma, B., Drug, V., Ciobanu-Apostol, D.G. (2022). *Is High Expression of Claudin-7 in Advanced Colorectal Carcinoma Associated with a Poor Survival Rate? A Comparative Statistical and Artificial Intelligence Study*. *Cancers*. <https://doi.org/10.3390/cancers14122915>

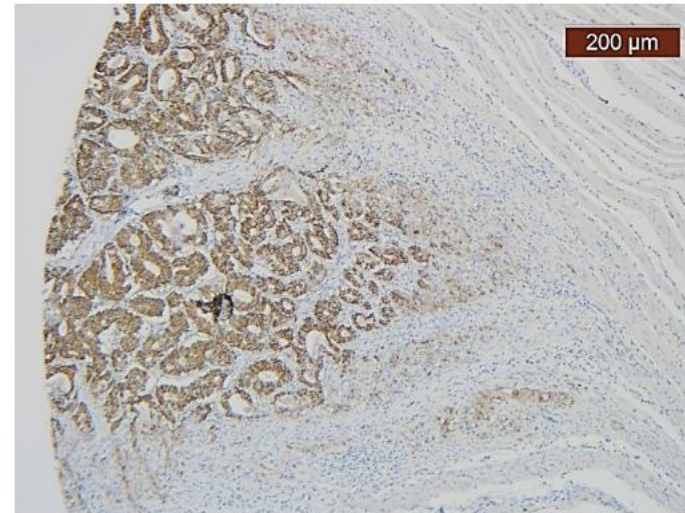
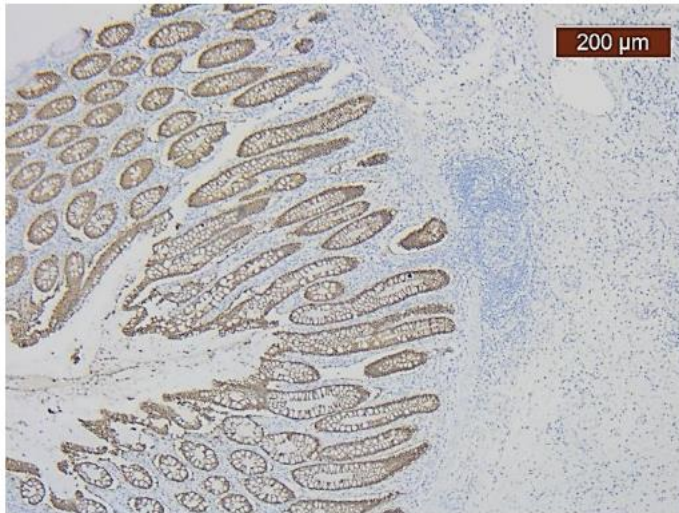


Understanding Claudin-7 in Advanced Colorectal Cancer

- Patients with advanced colorectal cancer (CRC) face high recurrence risks and need improved prognostic markers
- Claudin-7 is a protein essential for cell structure maintenance, which plays diverse roles in epithelial tissues, including tight junction regulation and tumor growth modulation
- The study investigated Claudin-7 expression levels in advanced CRC and their impact on prognosis
- It was found that high Claudin-7 expression at the invasion front correlates significantly with poorer overall survival rates
- A correlation was also found between Claudin-7 levels and inflammation
- The precise role of Claudin-7 in CRC (mechanisms, treatment) still remains unclear

Data Collection

- The study was conducted on 84 patients and the Claudin-7 expression levels in tissue samples were evaluated using immunohistochemistry (St. Spiridon Hospital in Iași)



Immunohistochemical profile of Claudin-7 in normal colonic mucosa (left) and CRC, intensity decreasing from core to invasive front (right)



Some Results

- Inputs: 6 Claudin-related attributes
- Output: survival rate (continuous or discretized)
- Despite some statistical correlations, the ML models could not predict the survival rate directly from Claudin levels

Algorithm	Training	Cross-validation
NN	60.7143 %	36.9048 %
kNN k =10, w = 1/d	60.7143 %	38.0952 %
NNGE	48.8095 %	45.2381 %
C4.5	51.1905 %	40.4762 %
Random Forest 100 trees	60.7143 %	39.2857 %
SVM RBF kernel	60.7143 %	34.5238 %
Linear model	59.5238 %	45.2381 %



Challenges in Applying AI Methods for Healthcare Data

- Establishing a causal model from the medical tests
 - The identification of the inputs and outputs of a model may not always be obvious
- Ethical responsibility
- Data quantity and quality
- Effects of possible natural adversarial examples



Possible Research Directions for Neuro-Symbolic Models

- Extensions of deep learning and deep reinforcement learning
 - Yann LeCun, Yoshua Bengio, Google DeepMind
- Methods closer to the structure and functioning of the brain
 - Assembly calculus
 - Processing based on cortical columns (e.g., hierarchical temporal memory, a thousand brains theory)
 - Cognitive psychology models (e.g., prototypes, exemplars, rules plus exceptions)
 - Leon, F. (2024). *A Review of Findings from Neuroscience and Cognitive Psychology as Possible Inspiration for the Path to Artificial General Intelligence*, Preprint, 143 pag., <https://doi.org/10.48550/arXiv.2401.10904>

Thank you for your attention!