Personalized Medicine: Enhancing Clinical Outcomes and Health System Efficiency through Novel Imaging Techniques

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Risk Stratification

Predicting Stroke Outcomes with MRI

- Utilize MRI data to identify rightward white matter lesion (WML) asymmetry as a proxy for carotid intraplaque hemorrhage (IPH).
- Older males (>70) with this imaging phenotype have a 4.57-fold higher risk of stroke within 2 years[1].
- Redefines the clinical focus for this high-risk cohort, currently ignored by guidelines[2], and enables aggressive interventions.

Scaling Precision in Breast Cancer Diagnosis

- Canada faces a critical shortage of breast cancer pathologists and traditional methods rely on manual assessment, which is prone to high inter-observer variability.
- AI algorithms provide an objective second opinion quantifying proliferative markers with a high level of precision and speed.
- By analyzing thousands of pathology features (morphology, spatial architecture, texture), AI can identify hidden phenotypes that manual inspection might overlook[3].

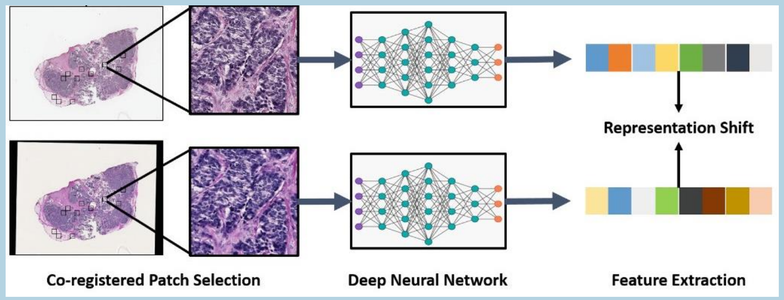

Figure 1: AI digital pathology framework used on breast tissue showing how to extract morphological features and identify high-risk phenotypes.

Canadian Policy Impact

- In Canada, the per patient one-year cost of a stroke[4] is $33,500, while treating Stage IV breast cancer[5] exceeds $137,000.
- AI-driven risk stratification shifts the system from reactive crisis management to proactive precision intervention.
- AI-driven risk stratification addresses the avoidable healthcare cost burden by reducing diagnostic wait-to-stage times.

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Disease Differentiation

Alzheimer's vs. Vascular Disease

- Alzheimer's disease (AD) and cerebrovascular disease (CVD) exhibit similar symptoms, yet their treatment pathways are fundamentally different.
- AI-driven classification of spatial white matter hyperintensities on MRI allows for the differentiation of AD and CVD[6].
- This enables clinicians to determine if a patient requires amyloid therapies (AD) or aggressive statin management (CVD).

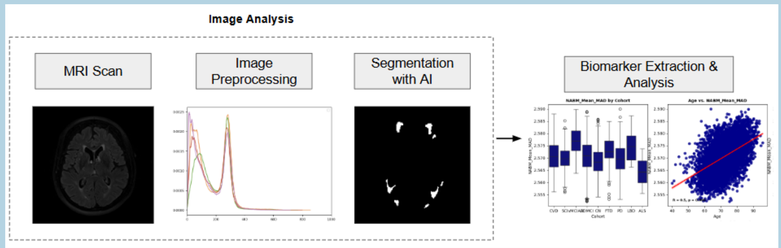

Figure 2: MRI processing pipeline workflow classifying white matter hyperintensities and extracting biomarkers to differentiate AD from CVD.

Improving Neuro-Psychiatric Drug Selection

- Without objective markers, patients suffering from major depressive disorder (MDD) often endure a cocktail of trial-and-error medications, increasing the risk of adverse drug events.
- Utilizing AI, EEG data can identify objective physiological signatures unique to each patient that can increase the likelihood of a positive patient response to treatment[7].
- We can further enable personalized treatments and/or pivot to targeted therapies (like rTMS or specialized rehab) immediately, bypassing months of ineffective drug cycles.

Canadian Policy Impact

- Differentiation reduces the annual $13.7B cost[8] of adverse drug events and ensures patients receive the right treatment.
- EEG and MRI biomarkers accelerate recovery and address the $51B annual loss[9] in Canadian productivity from brain disorders.
- Value-based prescription aligns with provincial mandates to provide equitable gold-standard care across all regions[10].

References
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Outlier Detection

Statistical Outlier Analysis

- Standard clinical trials and imaging software rely on group-wise comparisons but in heterogeneous diseases, the patient's unique pathology is undetected or discarded as noise.
- Outlier detection using medical images against a "Big Data" normative database enables personalized analysis[11].
- Mahalanobis, Generative Adversarial Networks (GANs), and Z-scoring methods can identify deviations from the norm[12].

Applications in mTBI

- Mild Traumatic Brain Injury (mTBI) is invisible on conventional CT/MRI, leaving patients without objective proof of symptoms.
- Applying Z-score profiling to MRI can pinpoint specific damaged clusters, which are often missed by radiologists, and provide a spatial and severity evaluation of a patient for a more comprehensive and personalized assessment of injury[13].
- Outlier detection provides objective proof, validates symptoms, and guides rehabilitation with improved data-driven metrics.

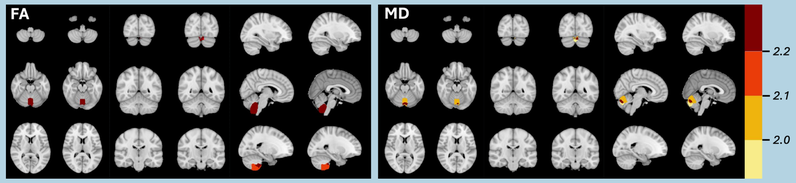

Figure 3: Severity maps of sagittal brain slices showing localized cerebellar damage clusters in a patient suffering from mTBI. Z-scores >2 standard deviations (significant injury) are colour coded orange to dark red to indicate increasing severity. Panels display standard MRI metrics of neuronal integrity labelled as FA (fractional anisotropy) and MD (mean diffusivity).

Canadian Policy Impact

- The FDA has cleared 950+ AI medical devices[14], with outlier detection growing 25% YoY. Canada must accelerate regulatory frameworks to grow innovations domestically.
- mTBI costs Canada $7B annually in lost productivity[15]. Objective diagnosis fast-tracks return-to-work timelines and drastically reduces the socio-economic burden.
- AI solutions can provide specialist diagnostics to all imaging communities, ensuring everyone has access to quality care.

References
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