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Dementia Prediction in Older Adults Using Sex-Specific Health Trajectory Clustering

Sunghwan Sohn

Associate Professor

AI & Informatics Dept. Mayo Clinic

AIDH IMIA

Burden of Dementia

✓Aging population increases persons with cognitive impairment (CI)
- > 44 M people with dementia worldwide -> estimated to triple by next three decades

✓Clinical diagnosis often occurs late
- Miss opportunities for maximizing quality of life
- Cause poor outcomes and burdens

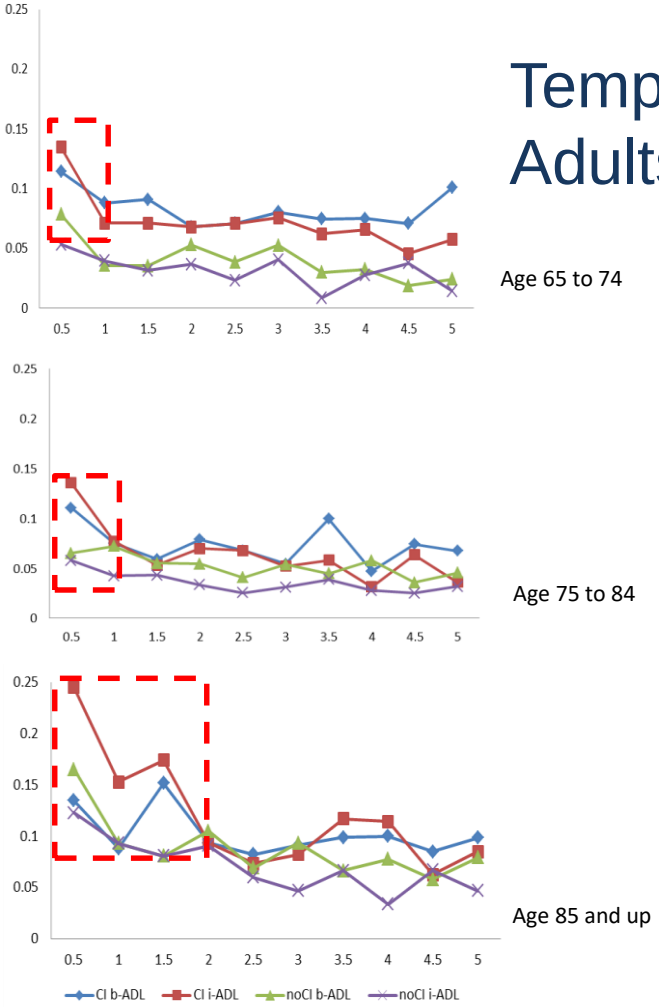
Early alert of CI is utmost importance!

Motivation

- Lack of approaches to monitor patient temporal health conditions in an unsupervised manner
  - Limited dementia cases and costly ascertainment
- Emerging evidence suggests variations in dementia risk and progression between males and females
  - One-size-fits-all approach overlooks sex-specific variation

Need for a "sex-specific" "unsupervised" dementia alert model accounting for "temporal" information!

Temporal Characteristics of Older Adults Cognitive Impairment



Age 65 to 74

Age 75 to 84

Age 85 and up

Activity of daily living (ADL) became much worse for cognitively impaired patients before diagnosis
- instrumental ADL worse than basic ADL

- ✓ Early signals of cognitive impairment in temporal health status
- ✓ Lack of approaches to characterize patient temporal health information in an unsupervised manner

x-axis: year(s) before the 1st physician-diagnosed CI for CI patients and the latest visit for non-CI patients
y-axis: a ratio of patients who have a deteriorated ADL

Early Temporal Characteristics of Elderly Patient Cognitive Impairment in Electronic Health Records. *BMC Medical Informatics and Decision Making, 2019*

Objectives

- To examine older adults' health changes to generate early alert (prediction) using streaming clustering
- To explore an impact of a sex-specific model to predict dementia onset

Dataset

- Mayo Clinic Study of Aging
  - Prospective population-based cohort study
    - Comprehensive periodic cognitive assessments
    - Repeated every 15 months
  - 6,185 patients; 26,807 visits (4.3/patient).
  - 49.6% Female
  - 729 patients (11.6%) progressed to dementia.
    - Only the visits **Prior** to Dementia used in the analysis.

Patient Demographics
Age, Sex, Race, Ethnicity
Physical characteristics
BMI, Smoking status, Alcohol problem
Sleep apnea, Hypertension, Dyslipidemia, Atrial fibrillation, Angina, Congestive heart failure, Coronary artery disease, Myocardial infarction, Coronary artery bypass graft, Diabetes, ESS score
Neuropsychiatric characteristics
Delusions, Hallucinations, Agitation, Depression, Anxiety, Euphoria, Apathy, Disinhibition, Irritability/lability, Motor behavior, Nighttime behavior, Appetite/eating change, BDI-II grand total, BDI depression (Total >=13), BAI total (0-63)
Social characteristics
Education, Occupation, Marital status, Personal care (as extracted from the clinical dementia rating scale)
Functional status
FAQ Total Score (0-30), ECog-12
Neuropsychological test scores
For four cognitive domains: (1) memory (AVLT delayed response, WMS-R Logical Memory II and Visual Reproduction II); (2) language (Boston Naming Test, Category Fluency); (3) attention/executive (Trail-Making Test B, WAIS-R Digit Symbol) and (4) visuospatial (WAIS-R Picture Completion and Block Design).

Streaming Clustering

- Temporal-based unsupervised techniques
  - Usually used to look for trends in streaming data
  - After initial cluster, a new instance will be determined whether it is outlier or not
    - Gaussian mixture model with possibilistic C-means
- Can incorporate temporal characteristics from multiple health visits
- Can generate early alerts for potential incidents of dementia.

Streaming Clustering Algorithm

Input: MCSA visit data for a participant
Output: dementia label = 0
For i = 1 : number of visits
    d = Mahalanobis distance to each cluster
    If d < outliner threshold
        assign it to the closest cluster
    Else flag it to outlier; dementia label = 1
    Endif
End

Results: Dementia Prediction

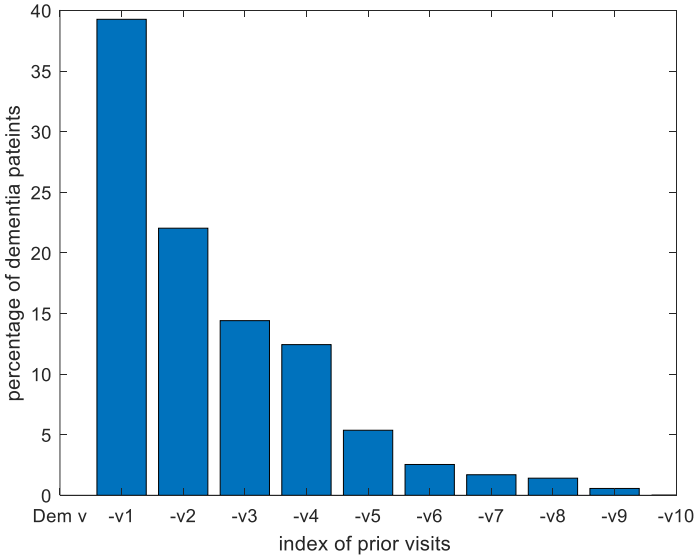
SC: original streaming clustering model
SC-NS: with added neuropsychological test score

Model	Precision	Recall	F1-Score
SC	0.56	0.75	0.64
SC-NS	0.62	0.68	0.65

With an age constraint (age >= 65)

Model	Precision	Recall	F1-Score
SC	0.60	0.78	0.68
SC-NS	0.65	0.77	0.71

Early Alert of Dementia (SC model)



Distribution of the index at which the model flagged a visit as outlier (dementia)

Early alert of elderly cognitive impairment using temporal streaming clustering, 2021 IEEE International Conference on Bioinformatics and Biomedicine

Results: Sex-specific Dementia Prediction

Model	Precision	Recall	F1-Score
SC-NS (M)	0.70	0.73	0.71 (0.65)
SC-NS (F)	0.73	0.72	0.72 (0.65)
SC-NS (M) age>=65	0.78	0.77	0.77 (0.71)
SC-NS (F) age>=65	0.76	0.80	0.78 (0.71)

( ) denotes the original model without sex separation
SC-NS: SC model with added neuropsychological test score features
(M): Male model, (F): Female model

Summary

- A streaming clustering predicts early signs of dementia
  - Can track changes from cognitive status
  - Unsupervised learning
- Sex-specific models improved prediction accuracy
  - Age constraint help improved prediction
- Sex-specific models may enable
  - Customized interventions leading to better outcomes
  - Mitigate biased AI models to ensure equitable prediction across genders

Thank you!