

# ADADL : Automatic Dementia Identification Model based on Activities of Daily Living using Smart Home Sensor data

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## Abstract

**DEMENTIA**  
is a chronic neurodegenerative disease, diagnosed mainly in the elderly over the age of 60 with mild cognitive impairment (MCI).

**Alzheimer's Disease International**  
Estimated growth in number of people with dementia 2019–2050\*  
2019: 55 million, 2030: 78 million, 2050: 139 million

Every 3 seconds someone in the world develops dementia

The total estimated annual worldwide cost of dementia is over US\$ 1.3 trillion. This figure is forecast to rise to US\$ 2.8 trillion by 2030\*

**Dementia Treatment**  
Medication, Mind-stimulating Activities, Therapy, Lifestyle Changes

**Example of Dementia progression**  
Cognitive level vs Time. Shows progression from Cognitively normal to MCI to Dementia. Early treatment (dashed line) slows progression, while late treatment (solid line) allows for faster decline.

The activity of daily living (ADL) assessment is a diagnostic tool used to identify patients with dementia. However, as the assessment is performed in a questionnaire format by patients, it depends on the subjective judgment of a clinician, which may cause an issue of poor accuracy. In this study, we have proposed **an objective ADL assessment method that utilizes smart home data for efficient identification of early dementia**. For data collection, we **built IoT sensor-based smart homes** and performed clinical trials. Through pre-processing and analysis of the collected data, **we generated new features that reflect ADL and patient characteristics**. To build the dementia prediction model, **three machine learning and deep learning models** were trained on the collected and generated features. The performance of each model was compared for combinations of each feature set. Thus, it was determined that **the ADL and patient characteristics-based features contributed mainly to the prediction**. Consequently, the proposed method can be developed as a baseline for more efficient and objective ADL assessments that can be performed by monitoring patients without any domain knowledge.

## Methodology

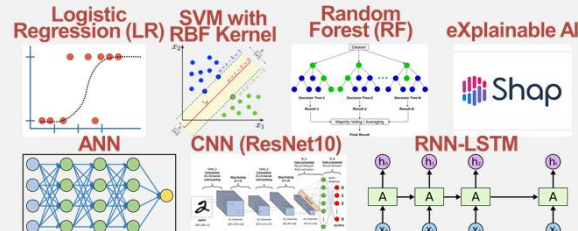
### Recruitment of Clinical Trial Subjects

✓ 13 Elderly people living alone in Seoul, Korea

Category	Age	MMSE	Category	Age	MMSE
Normal group (n=7)	86	26	Dementia group (n=6)	87	20
	79	29		76	13
	84	25		86	18
	72	27		76	23
	67	26		85	11
74	30	72	14		
90	30				
Average	78.8	27.5	Average	80.3	16.5



### Training and Evaluation of Dementia Prediction Model



### Building IoT Sensor-based Smart Homes

✓ Sensor data for each participant were collected through clinical trials for 13 months (2020–2021).



### Generate ADL-based Features

✓ Referring to S-IADL and using IoT sensor data, ADL-based features for 7 activities are generated.

Seoul-Instrumental Activities of Daily Living (S-IADL)

Activity	Generated Features
Using Phone	Using household appliances, Belongings, Appointment
Shopping	Recent Memory, Hobbies
Cooking	Using household appliances, Belongings, Appointment
Household chores	Using household appliances, Belongings, Appointment
Using Public transport	Recent Memory, Hobbies
Going out	Recent Memory, Hobbies
Taking medicine	Recent Memory, Hobbies

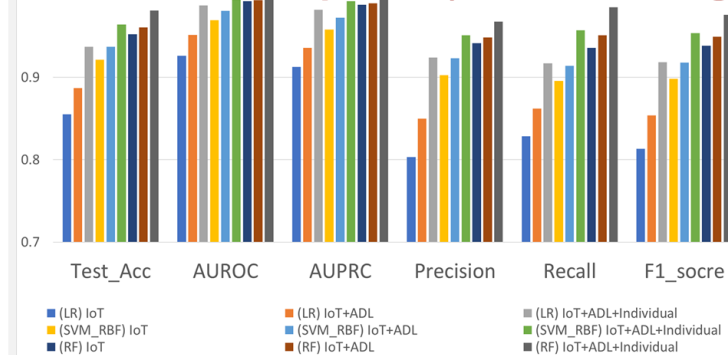
### Generate Individual Characteristics-based Features

✓ Characteristics-based Features were created through analysis of IoT sensor-based features and ADL-based features.

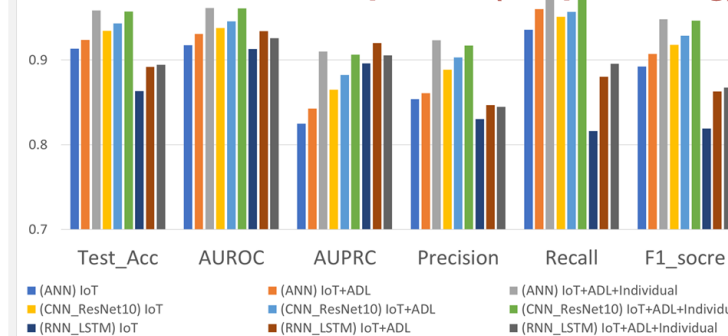
Category (MMSE)	Cognitive Level	Outlier Criteria
Normal (30 – 24)	No Cognitive Decline	Q1 – 1.5 * IQR > Value Q3 + 1.5 * IQR < Value
	Very Mild Cognitive Decline	Q1 – 1.2 * IQR > Value Q3 + 1.2 * IQR < Value
Dementia (23 – 0)	Mild Cognitive Decline	Q1 – 1.0 * IQR > Value Q3 + 1.0 * IQR < Value
	Moderate Cognitive Decline	Q1 – 0.5 * IQR > Value Q3 + 0.5 * IQR < Value

## Results

### Performance Comparison (Machine Learning)



### Performance Comparison (Deep Learning)



### Top 10 features of predictive contribution on Random forest-based proposed Model

Rank	Features
1	(Individual) IoT noon TV watching duration
2	IoT morning TV watching duration
3	(Individual) ADL cooking duration
4	ADL morning TV watching duration
5	(Individual) ADL cooking duration (refrigerator–gas stove)
6	IoT morning TV watching count
7	IoT bathroom sink faucet duration
8	ADL shower duration
9	IoT evening electric mat count
10	ADL household chores washing dishes duration