

Serious Games and ML for Detecting MCI

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Background

- Mild Cognitive Impairment (MCI):
 - Subtle symptoms → hard to detect
 - Precursor to dementia
 - Early detection → more effective therapeutics
- Serious Game (SG) for MCI detection, not mental training



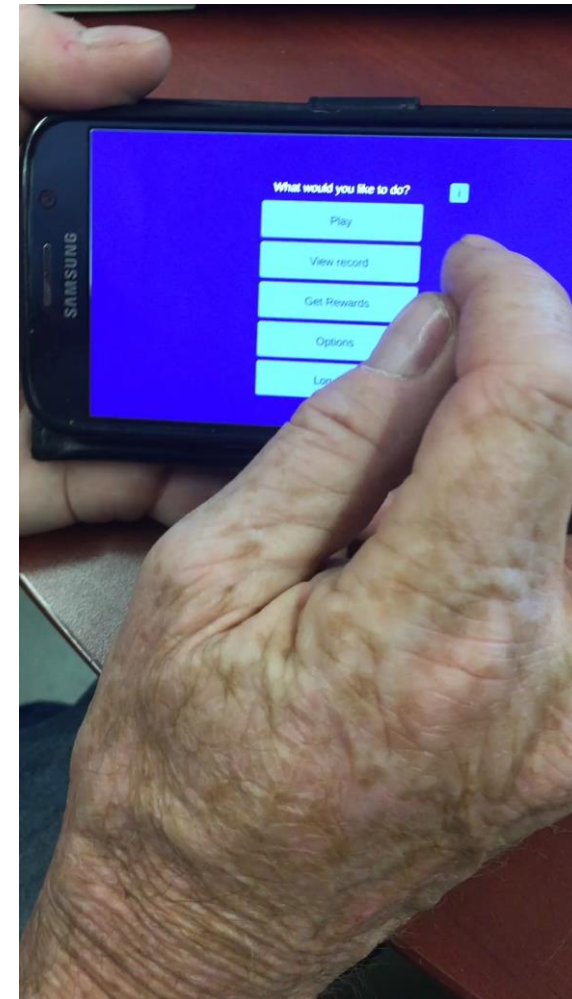
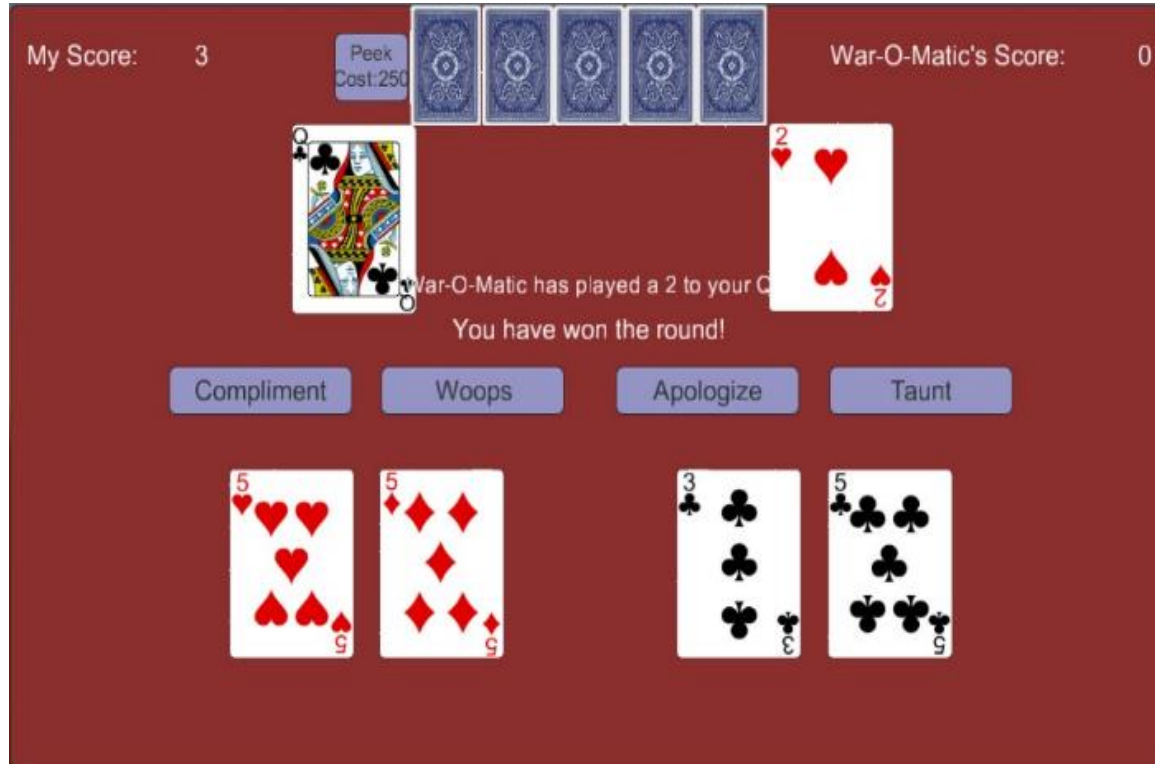
The Serious Game “WarCAT”

- Based of the familiar card game “**War**”
- Denoted **WarCAT** for **War Cognitive Assessment Tool**
- Can be played on smart phones & tablets
- The **android** version can be downloaded from:

home.cc.umanitoba.ca/~mcleod



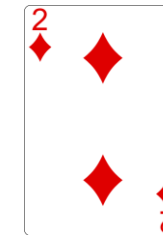
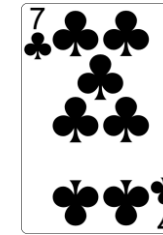
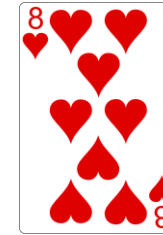
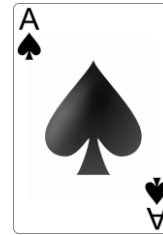
An example of play



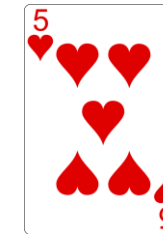
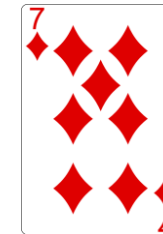
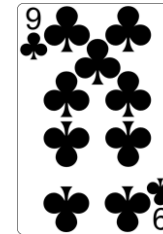
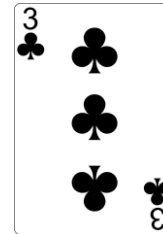
WarCAT

order of play →

Computer's Cards



Player's Cards



- An example of countering the computer's strategy

- Winning by a thin margin → higher score

- $$Score = 13 - \left[\left(\begin{matrix} \text{Winning Card} \\ \text{Value} \end{matrix} \right) - \left(\begin{matrix} \text{Losing Card} \\ \text{Value} \end{matrix} \right) \right]$$

Loss
-2

Win
+11

Win
+12

Tie
0

Win
+10



ML Approach

Player → Game → Game-Play Data → ML Classifier → Result



ML Approach

Player → Game → Game-Play Data → ML Classifier → Result

RL bot → Synthetic Data

```
graph TD; RL_bot[RL bot] --> Synthetic_Data[Synthetic Data]; Synthetic_Data --> Game_Play_Data[Game-Play Data]; Game_Play_Data --> ML_Classifier[ML Classifier]; ML_Classifier --> Result[Result];
```



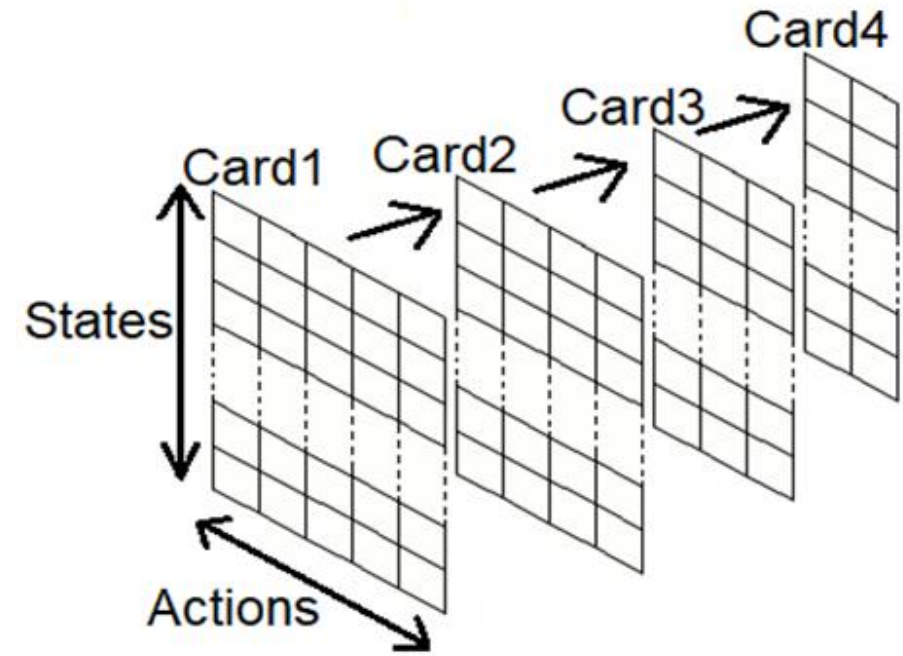
Reinforcement Learning (RL)

- Similar to Human Learning
- Goal is to imitate human-like behavior of play, not develop a superhuman bot



Q-Learning Algorithm

- Tabular Q-Learning
- Each State has Q-Values



$$\underbrace{Q^{new}}_{\text{Table Card } n} \leftarrow \underbrace{Q^{old}}_{\text{Table Card } n} + \underbrace{\alpha}_{\text{Learning Rate}} * \left(\underbrace{r}_{\text{reward}} + \underbrace{\gamma}_{\text{discount factor}} * \max \underbrace{Q}_{\substack{\text{Table Card } n+1 \\ \text{estimate of optimal} \\ \text{future value}}} \right)$$

RL Results

- Human Level Score Avg. <18.6

Epochs (Millions)	Score Average
0	0.18304
1	11.86888
2	12.40905
5	13.58131
10	14.33171
15	15.17609
30	16.16207
50	17.17993
100	17.9266
200	18.47558
230	18.58362
275	18.64247
400	18.73655
660	18.8828

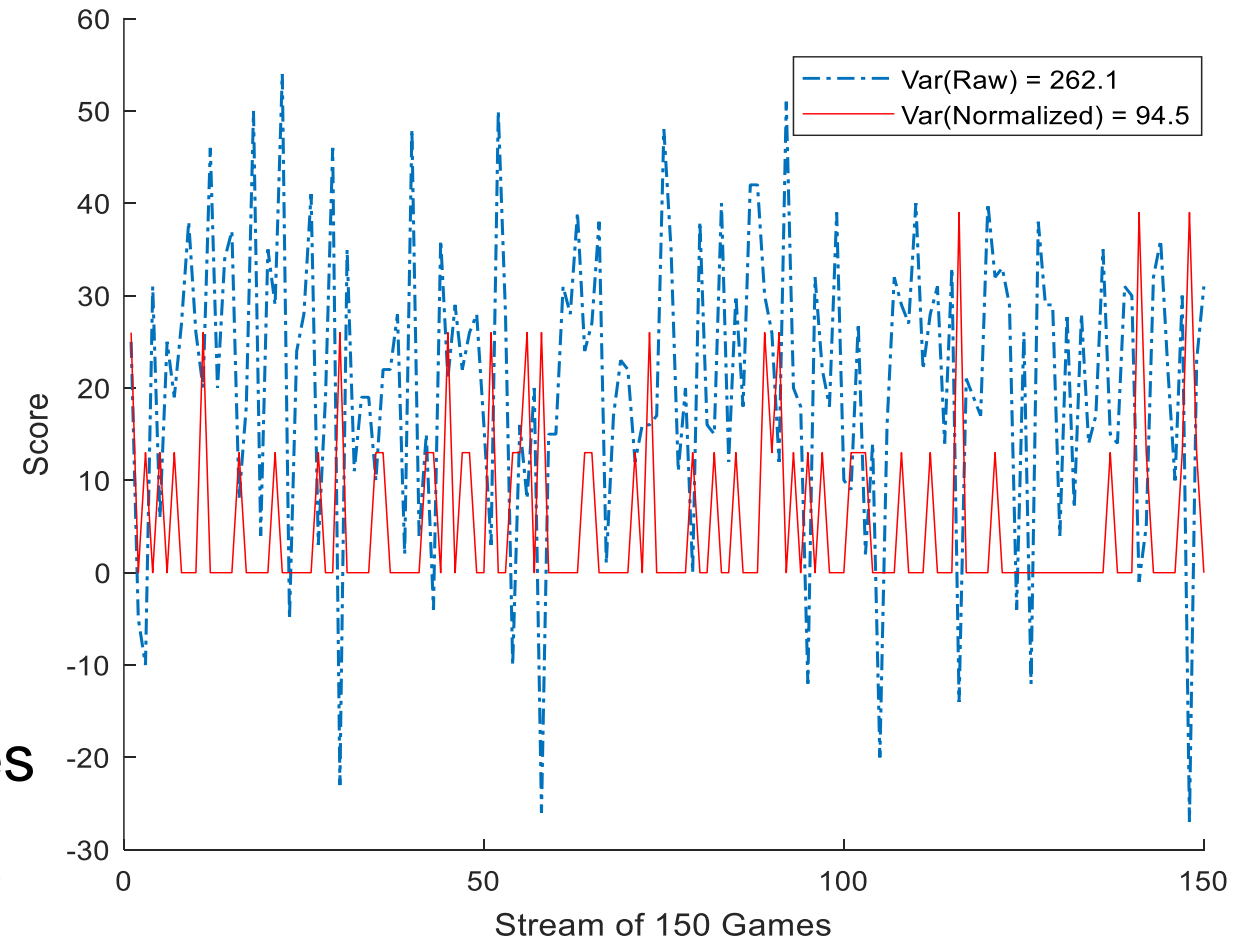
RL Results

- Human Level Score Avg. <18.6
- **Synthetic Data (5 Classes)**

Epochs (Millions)	Score Average
1	11.86888
5	13.58131
15	15.17609
50	17.17993
660	18.8828

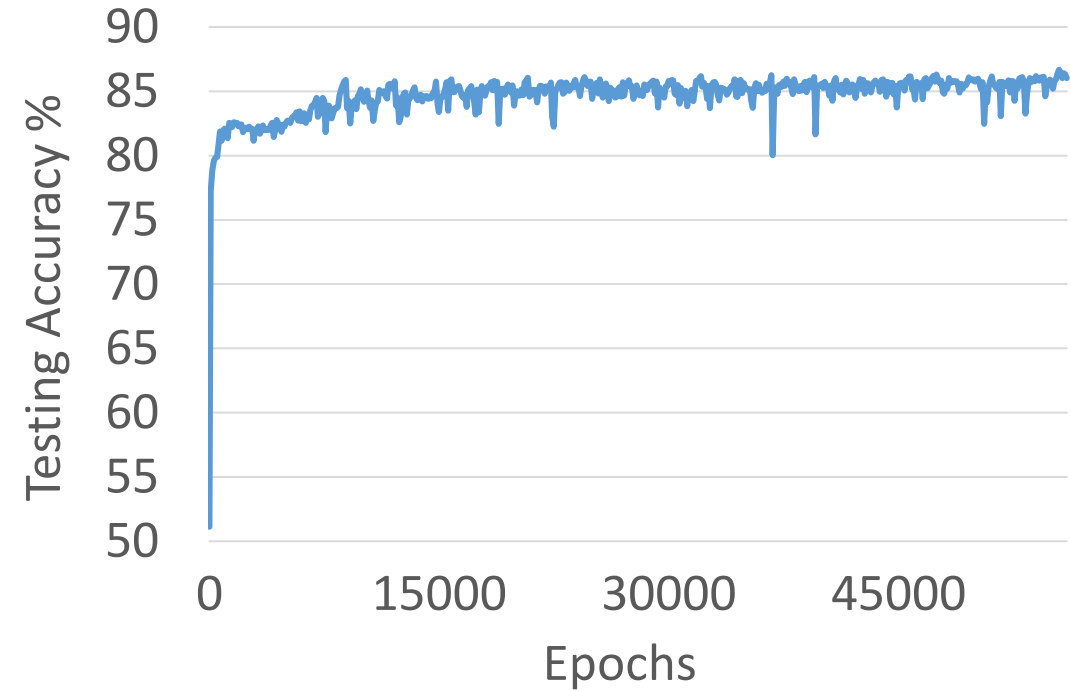
ML Classifier

- Raw Data: stream of 150 games
- Residual From Max Score →
Reduce Variance
- Avg. of (150 scores) & Avg.
of (150 Max scores)
- Data becomes a stream of 152 values
- Convolutional Neural Network (**CNN**)



CNN Classifier

Class	Score Average
RL Class1	11.88046
RL Class2	13.59851
RL Class3	15.0722
RL Class4	17.23785
RL Class5	18.92467

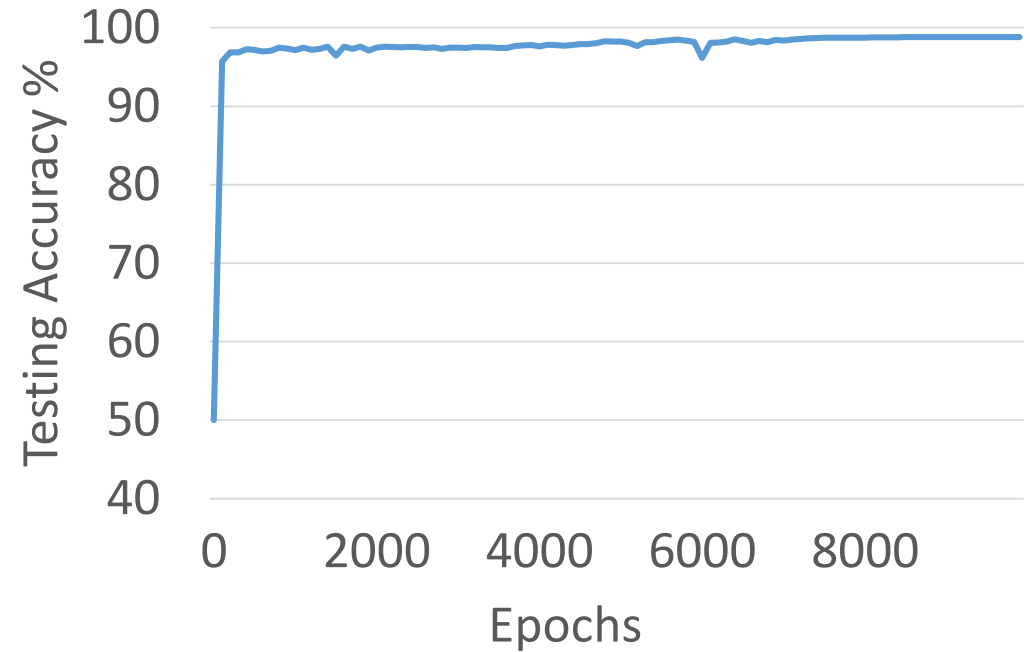


→ } 86.4% Classification Accuracy
→ }



CNN Classifier

Class	Score Average
RL Class1	11.88046
RL Class2	13.59851
RL Class3	15.0722
RL Class4	17.23785
RL Class5	18.92467



→ } **98.8% Classification Accuracy** ←

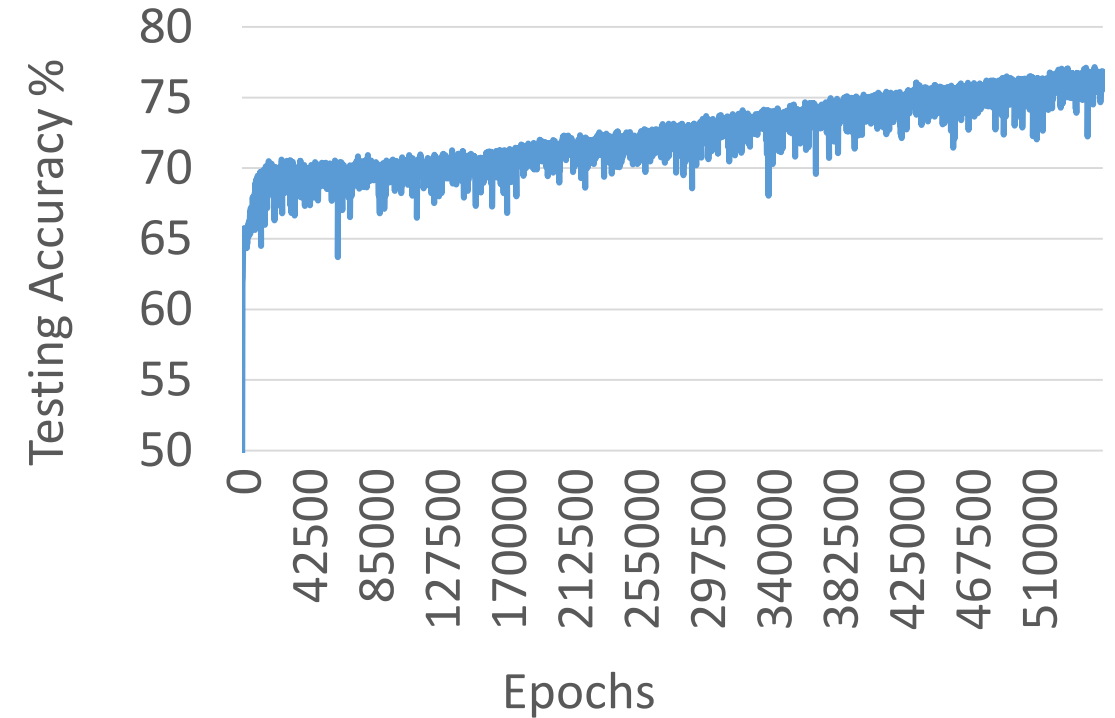


CNN Classifier

- Two Classes (closer score avg.)
- RL Bot & Basic Strategy.

Class	Score Average
Basic Strat.	14.73
RL Class3	15.0722

→ } 76.4% Classification Accuracy
→ }



Summary

- Detecting MCI through WarCAT SG & ML algorithms
- ML algorithms are used in two ways:
 - RL Bot (trained by trial and error) to generate synthetic data
 - CNN classifier (Trained on synthetic data)
- CNN classifier can distinguish two RL learning stages with 1.69 average score performance difference with 86.4% accuracy
- A higher average score difference gives even greater discrimination accuracy.
- These results bode well in justifying ML approaches within SGs to help in the early detection of MCI.



Thanks!



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