Fukushima Prefectural Fukushima High School

Creating a Mahjong-Hand-Prediction Model Using a diffusion model

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(1)Problem/Question

Introduction

The purpose is to create an AI for imperfect information games like mahjong. These games include randomness and not all information is available on the board.

Predicting these games is more difficult compared to games with certain and perfect information like Othello and Chess.

Prior research

Most Mahjong AIs researched so far are CNNs (Convolutional Neural Networks).
The problem with CNNs is that they have only produced one plausible prediction.
Therefore, this method is not optimal for predicting mahjong hands, which have several uncertainties

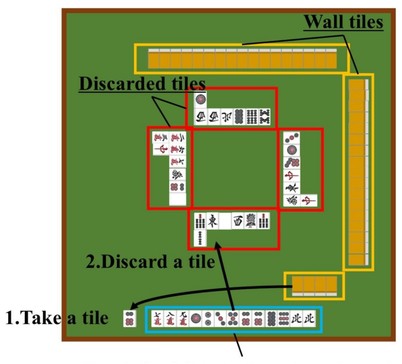
	Perfect information on the board	Imperfect information on the board
Not included randomness	Chess  Othello 	
Included randomness	Concentration  Sugoroku 	Mahjong 

Explanation of basic mahjong terms and rules

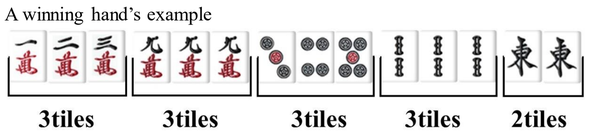
This section explains the terms and rules related to this study.

Mahjong is played by four players

mahjong tiles consist of 37 types of tiles, with four tiles of each type



A winning hand's example



A winning hand is formed by arranging consecutive numbers or matching colors and numbers.

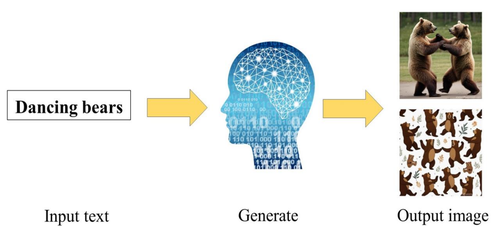
- These rules allow players to make some predictions about the other players' hands based on the discarded tiles.

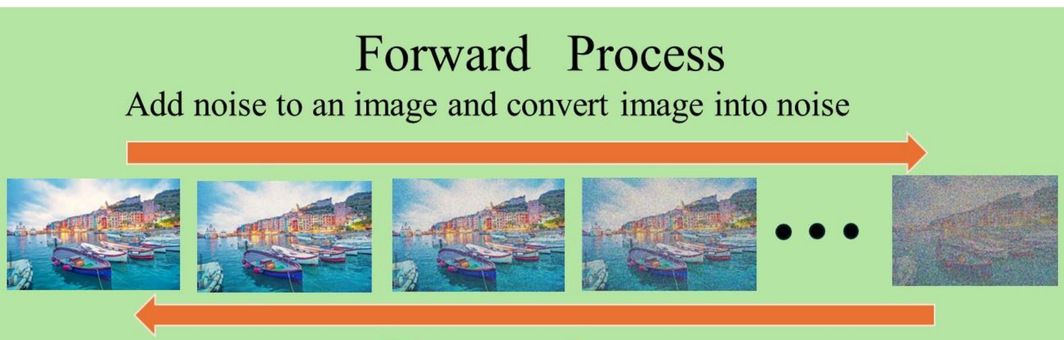
Therefore, the purpose of this study is to develop an AI for making these predictions.

2.Framework/Project Design

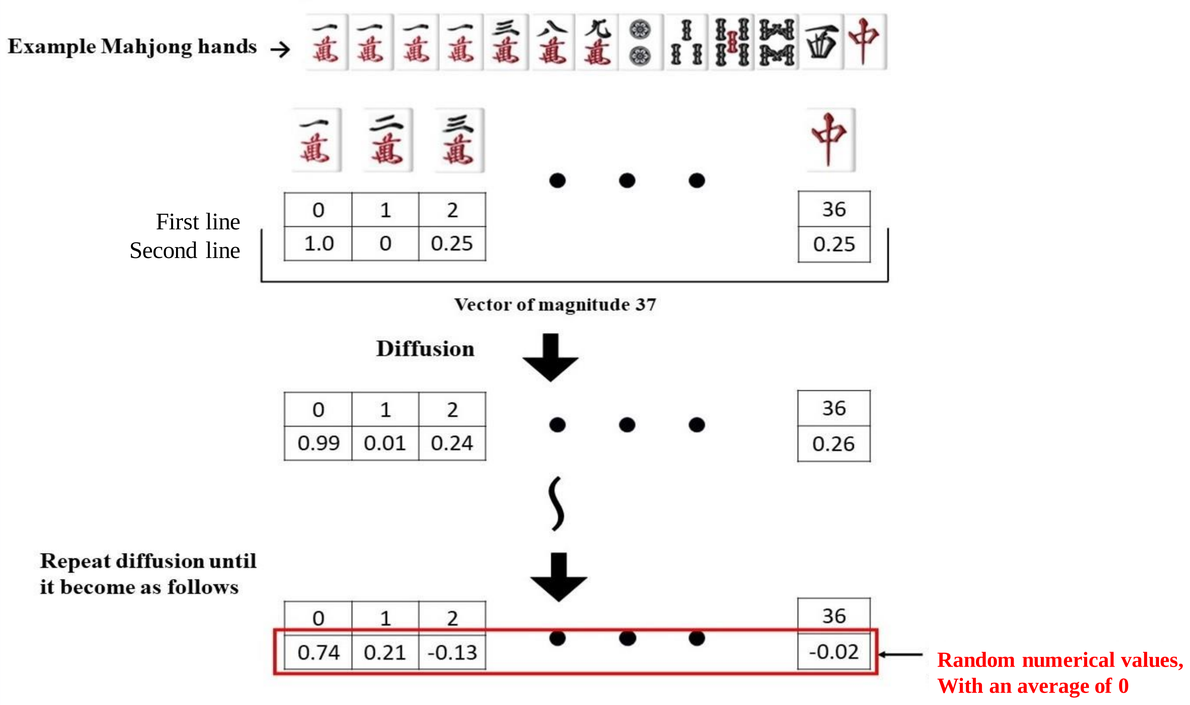
Train using a diffusion model.
Diffusion models are used in various AI applications, but are mainly employed in image generation AI.

Advantages of a diffusion model is what it can generate multiple predictions.





＜Forward Process image＞



- First line: Nth element of the vector.
- Second line: Values converted from each tile in the obtained mahjong hands into numerical values.
  →V = .25x where V is the default value and x is the numerical value ∴ {(x,V) , (0,0) (1,0.25) … (4,1.0)}

1. Obtain the data of the mahjong hands on the board .
2. Convert each tile in the obtained mahjong hands into numerical values and defining it as a vector of magnitude 37 (equal to the number of types of tiles).
3. Increase and decrease the numerical values.
   Finally, the numerical values obey a standard normal distribution (random values with the average of the 37 values being 0).
4. The reverse the forward process and predict the original numerical values from random values.

3. Finding

Train AI with 10,000 and 100,000 data points.
It's prediction of the hand based on a certain discarded tiles produced the following outputs.

Hands example 

Discarded tiles' example 

10,000 data

First Prediction  Probability: 1.0% Accuracy: 0.46153

Second Prediction  Probability: 1.0% Accuracy: 0.5384

Third Prediction  Probability: 1.0% Accuracy: 0.5384

100,000 data

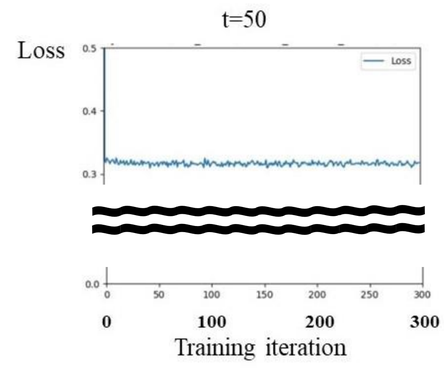
First Prediction  Probability: 1.0% Accuracy: 0.4615

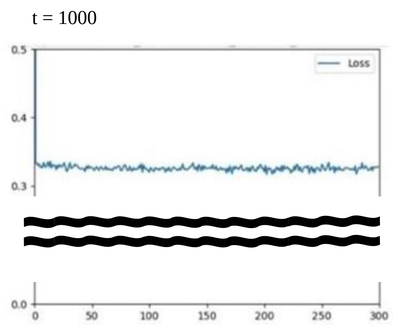
Second Prediction  Probability: 1.0% Accuracy: 0.3846

Third Prediction  Probability: 1.0% Accuracy: 0.3846

the accuracy showed little change even when the number of data used for training increased from 10,000 to 100,000.

This figures are graphs showing the loss values for each training iteration with 10,000 data points and t=50 and 1,000.





t: the number of times noise is added
Loss: mean squared error between the prediction and the actual mahjong hands

The loss is not decreasing.
The same results occurred even when increasing the number of training iterations or changing the value of t.

Based on the above, there is little reduction in the error between the AI's predictions and the actual results, regardless of the amount of data or the number of training iterations, suggesting that the AI's predictions of the hand are not successful.

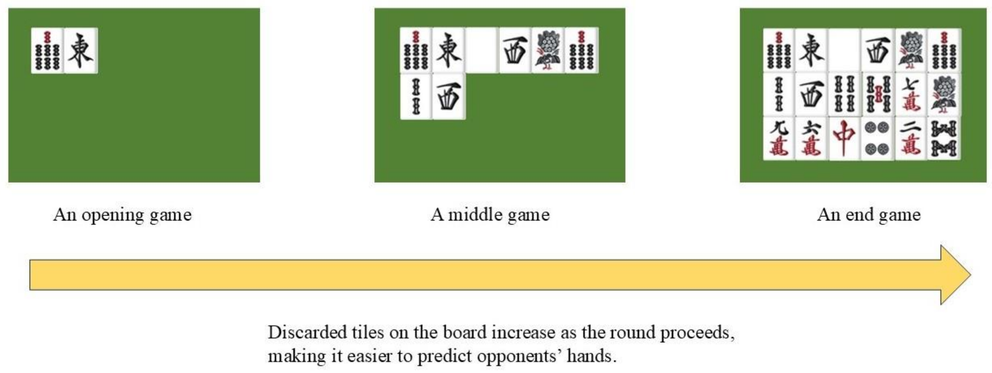
4. Interpretation and Conclusion, Discussion

The failure of AI learning can be attributed to the following factors.

1. Lack of learning data
   For convenience of the research environment, because each AI learning iteration takes a long time, using a lot of data for learning was impossible.
   To increase the learning speed and handle a larger dataset, we have purchased a CUDA-compatible GPU, allowing us to train the model with more data than before.

2. Problem of evaluation method

Discarded tiles' example



Though the present evaluation method evaluates the Loss in the same way regardless of round progression, change it to evaluating the Loss separately by round progression.

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References

[Ogami et al.] 大神 卓也, 奈良 亮耶, 天野 克敏, 今宿 祐希, 鶴岡 慶雅. 2022. "Transformerを用いた麻雀における手牌推定." ゲームプログラミングワークショップ2022論文集, 151–58.