ネットワークプログラミングⅡ

—麻雀ゲームの作成—

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1　作成したプログラム

オンライン対戦可能な麻雀ゲームを作成した。ルールはオーソドックスな日本のリーチ麻雀であるが、3人/4 人対戦どちらも対応していたり、AI を交えた対戦が可能であったりと、細かな機能を充実させた。また、操作は CUI で行うが、OpenCV を用いることで卓上の状態をグラフィカルに表示した。

使用したプログラミング言語は、Python 3.7.4 である。

2　動作説明

麻雀で行う主な動作について、サーバー側とプレイヤー側でどのような動作をしているかを示す。

2.1　ポン

図 1 から図 3 にポンをした時の動作を示す。

図 1　ポンの動作（サーバー）

サーバーではポンをしたプレイヤーの手牌からポンの構成牌がなくなっている。コンソールではポンするかどうかに対し、y(yes) を入力している。これに対し GUI にはポンの様子が表示されている。

2.2　チー

図 4 から図 6 にチーをした時の動作を示す。

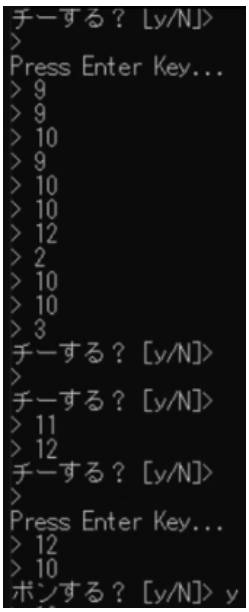

図２　ポンの動作（コンソール）

図３　ポンの動作（GUI）

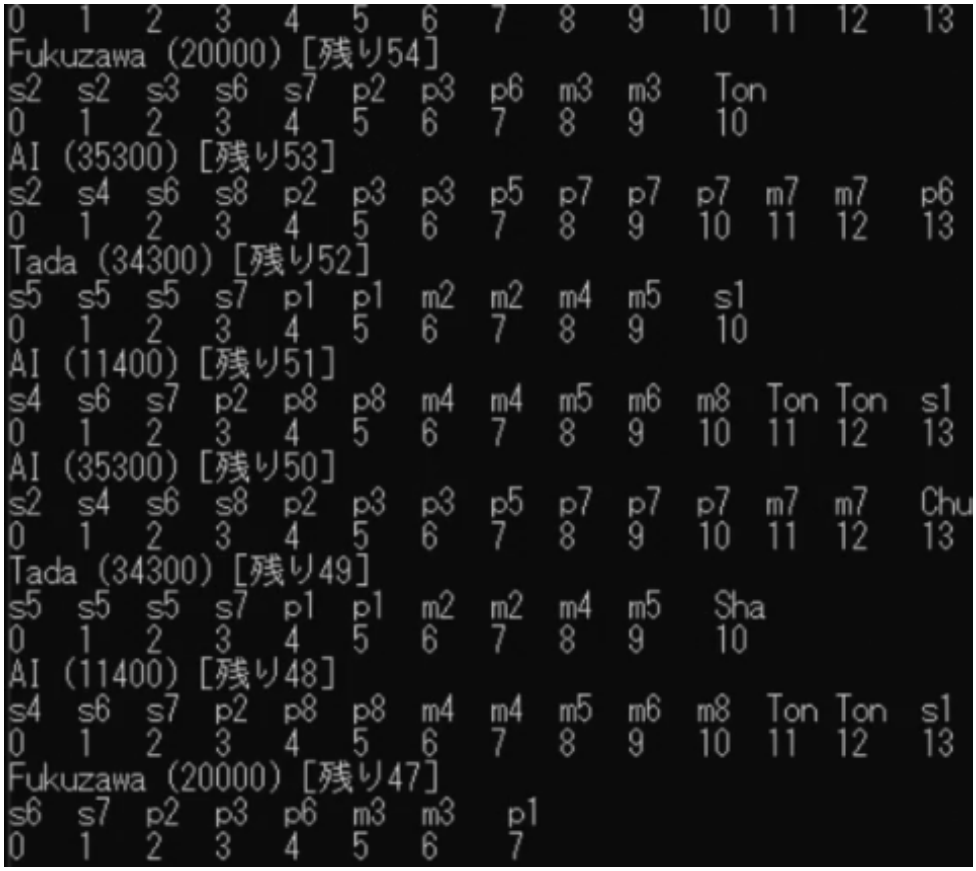

図 4　チーの動作（サーバー）

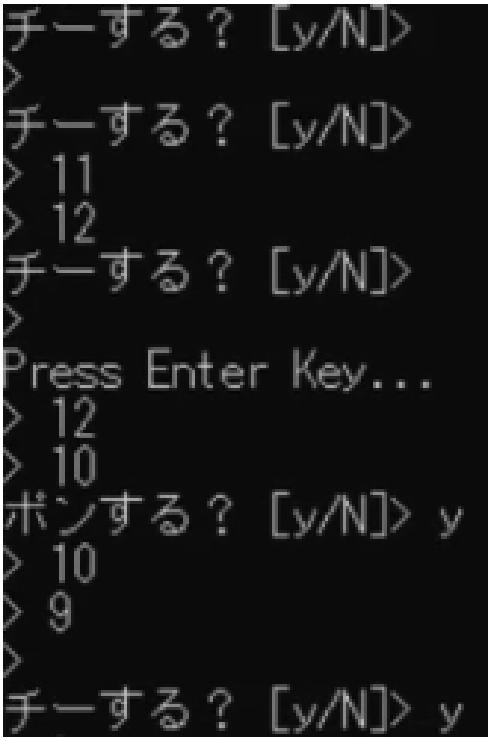

図 5　チーの動作（コンソール）

図 6　チーの動作（GUI）

サーバーでは、チーをしたプレイヤーが以前にポンをしていたため、手牌から 2 鳴き分の構成牌が消えている。コンソールではチーするかどうかに対し、y(yes) を入力している。これに対し GUI にはチーの様子が表示されている。

2.3　暗カン

図 7 から図 8 に暗カンをした時の動作を示す。

サーバーでは暗カンをしたプレイヤーの手牌から暗カンに使われた牌が消えている。AI が暗カンをしたためコンソールの表示はないが、GUI には暗カンの様子が表示されている。

2.4　明カン

図 9 から図 11 に明カンをした時の動作を示す。

サーバーでは明カンを舌プレイヤーの手牌から明カンに使われた牌が消えている。コンソールでは暗カンするかどうかに対し、y(yes) が入力されている。これに対し GUI には明カンの様子が表示されている。

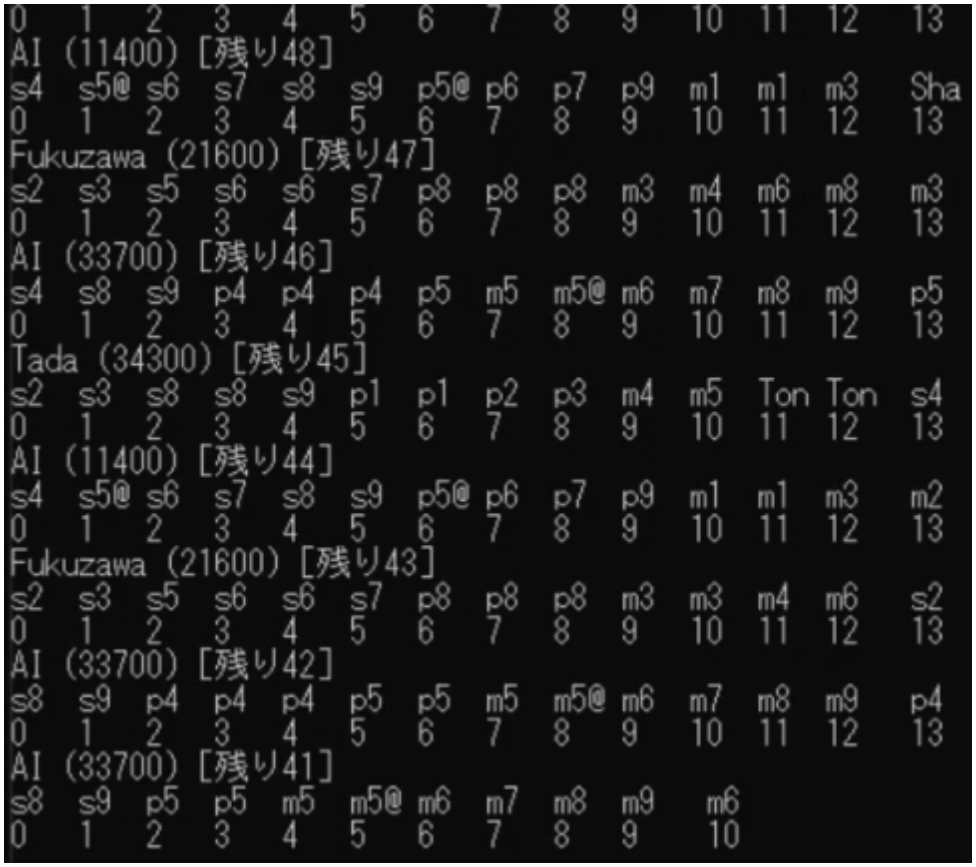

図 7　暗カンの動作（サーバー）

2.5　ロン

図 12 から図 14 にロンをした時の動作を示す。

サーバーではロンに関わったプレイヤーと、役の内容が表示されている。コンソールではロンするかどうかに対し y(yes) が入力されている。これに対し GUI ではロンをした牌が赤みがかり、ロンを表現している。

2.6　ツモ

図 15 から図 17 に打牌時の動作を示す。

サーバーではツモをしたプレイヤーと、役の内容が表示されている。コンソールではツモをするかどうかに対し y(yes) を入力している。これに対し GUI にはツモった牌を表示している。

2.7　流局

図 18 から図 19 に流局した時の動作を示す。

サーバーでは各プレイヤーのテンパイ状況を表示している。これに対し GUI ではテンパイのプレイヤーの手牌が倒されて表示されている。

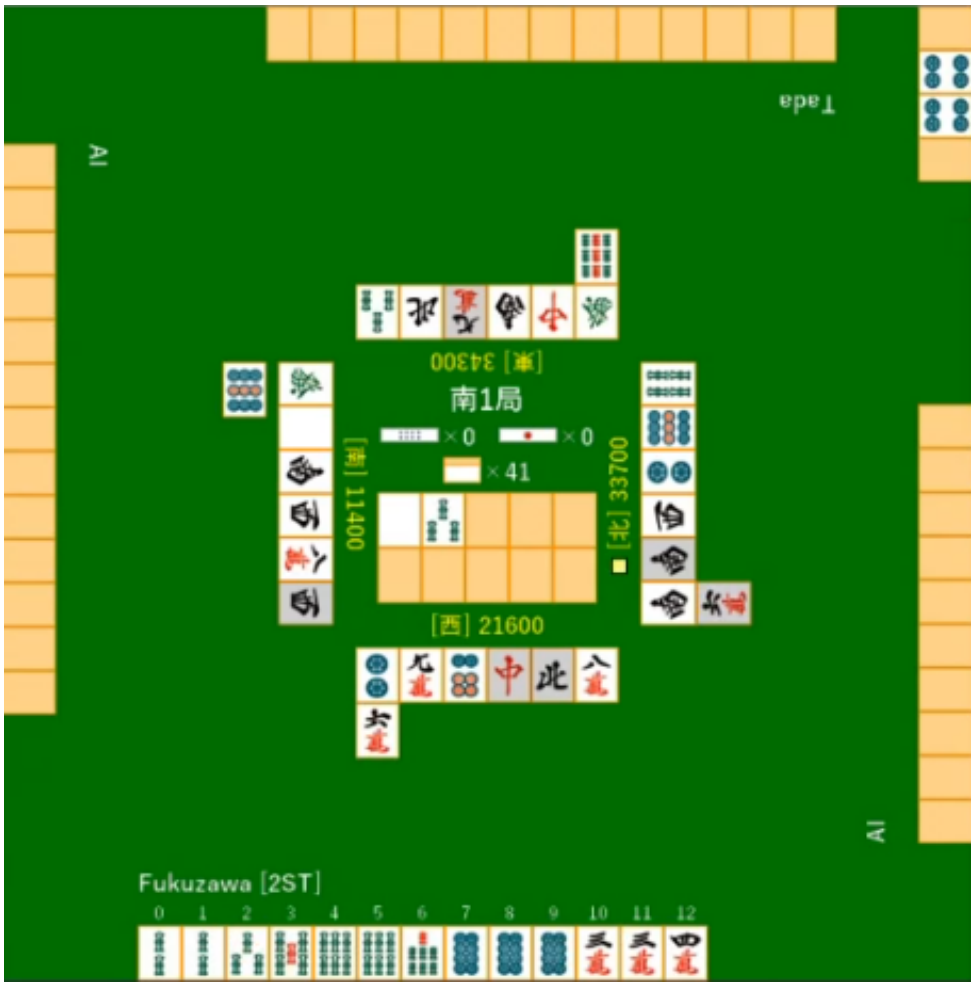

図 8　暗カンの動作（GUI）

図 9　明カンの動作（サーバー）

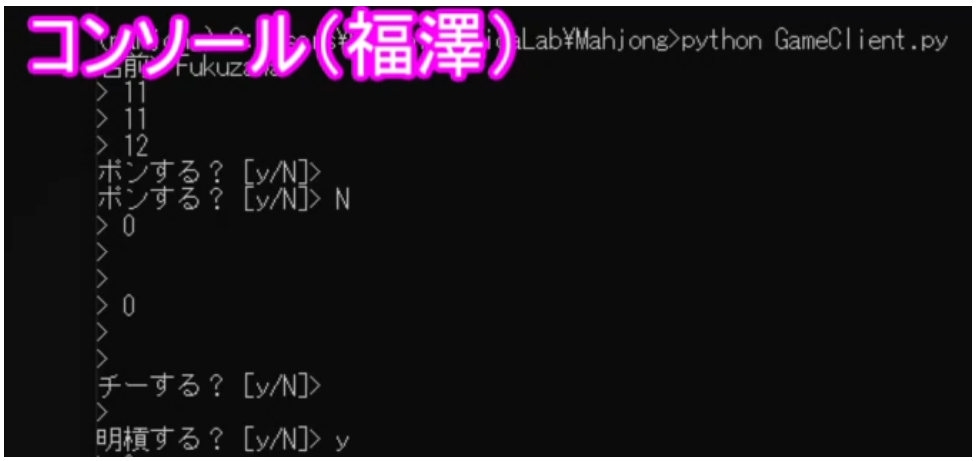

図 10　明カンの動作（コンソール）

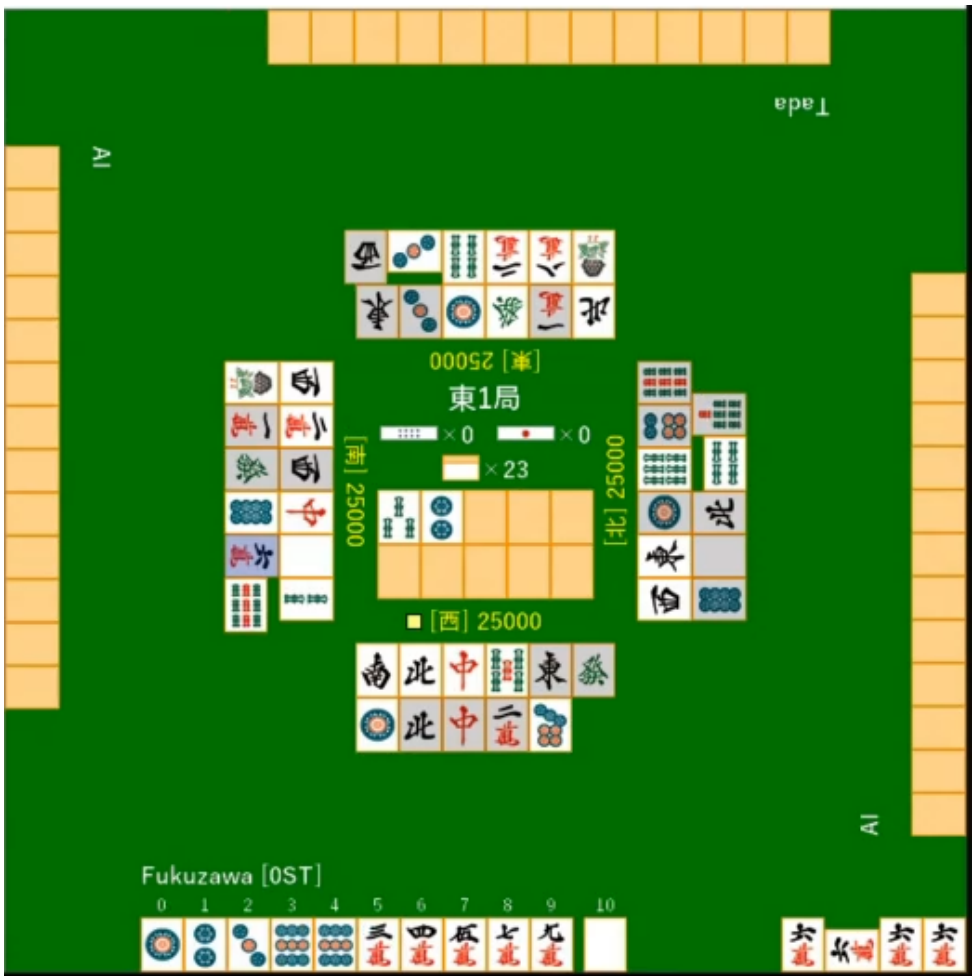

図 11　明カンの動作（GUI）

図 12　ロンの動作（サーバー）

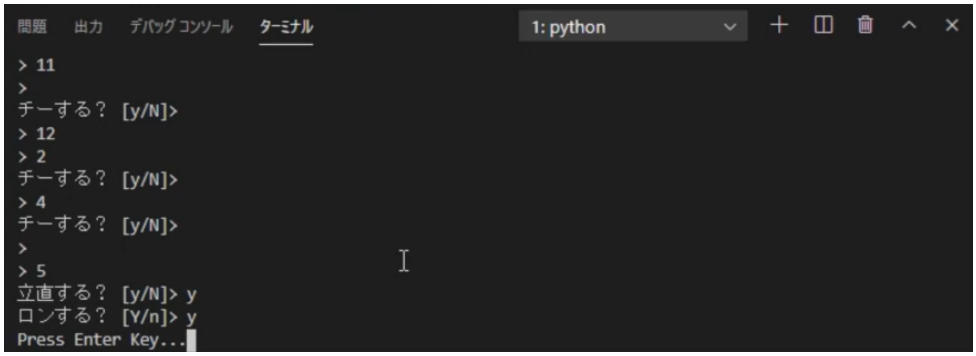

図 13　ロンの動作（コンソール）

3　クラス図

本システムのクラス図を図 20 に示す。詳細な説明は省略するが、ゲームの進行を表す Game クラスを GameServer クラスに継承し、ソケット通信でオンライン対戦を行う機能をオーバーライドしている。

4　ファイル構造

本システムのファイル構造を図 21 に示す。GameServer.py はサーバーサイドのプログラム、GameClient.py はクライアントサイドのプログラムである。その他の麻雀システムのプログラムは mjgame フォルダ内にまとめられている。

図 14　ロンの動作（GUI）

図 15　ツモの動作（サーバー）

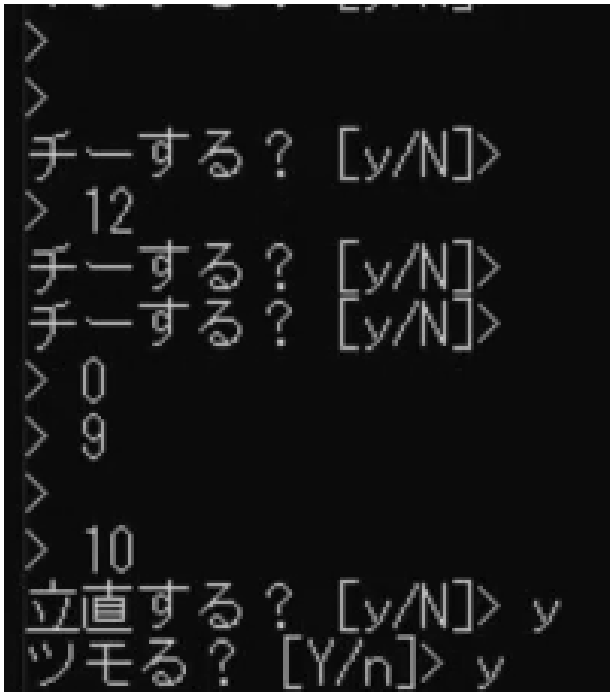

図 16　ツモの動作（コンソール）

図 17　ツモの動作（GUI）

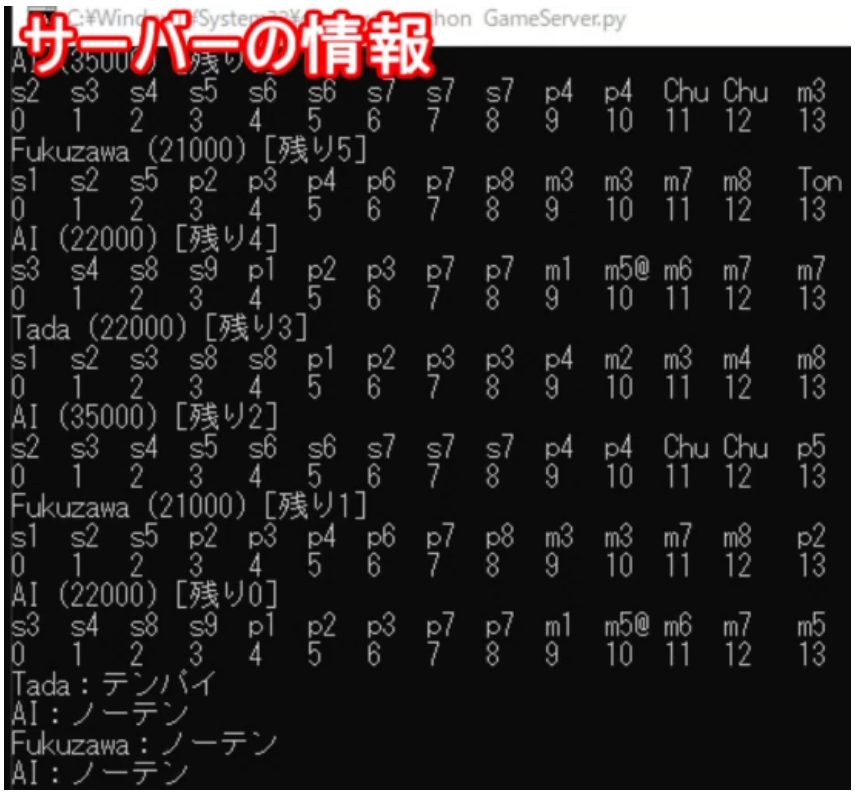

図 18　流局の動作（サーバー）

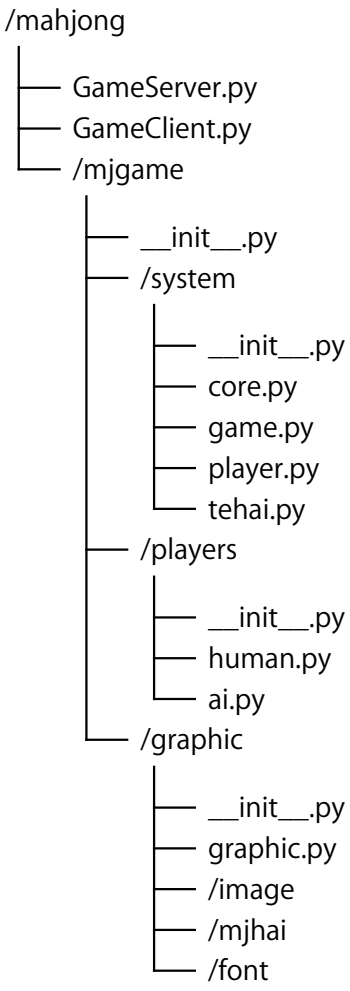

図 21　ファイル構造

図 19　流局の動作（GUI）

5　プログラムリスト

サーバーサイドのプログラムをリスト 1 に、クライアントサイドのプログラムをリスト 2 に示す。その他の麻雀システムのプログラムはリスト 3–13 に示す。

リスト 1　GameServer.py

```
1  import time
2  import random
3  import copy
4  import pickle
5  import socket
6
7  import mjgame.system as mj
8  import mjgame.players as mp
9
10 # 通信する処理の種類
11 class EventKind():
12     UPDATE   = b"upd"
13     DAHAI    = b"dah"
```

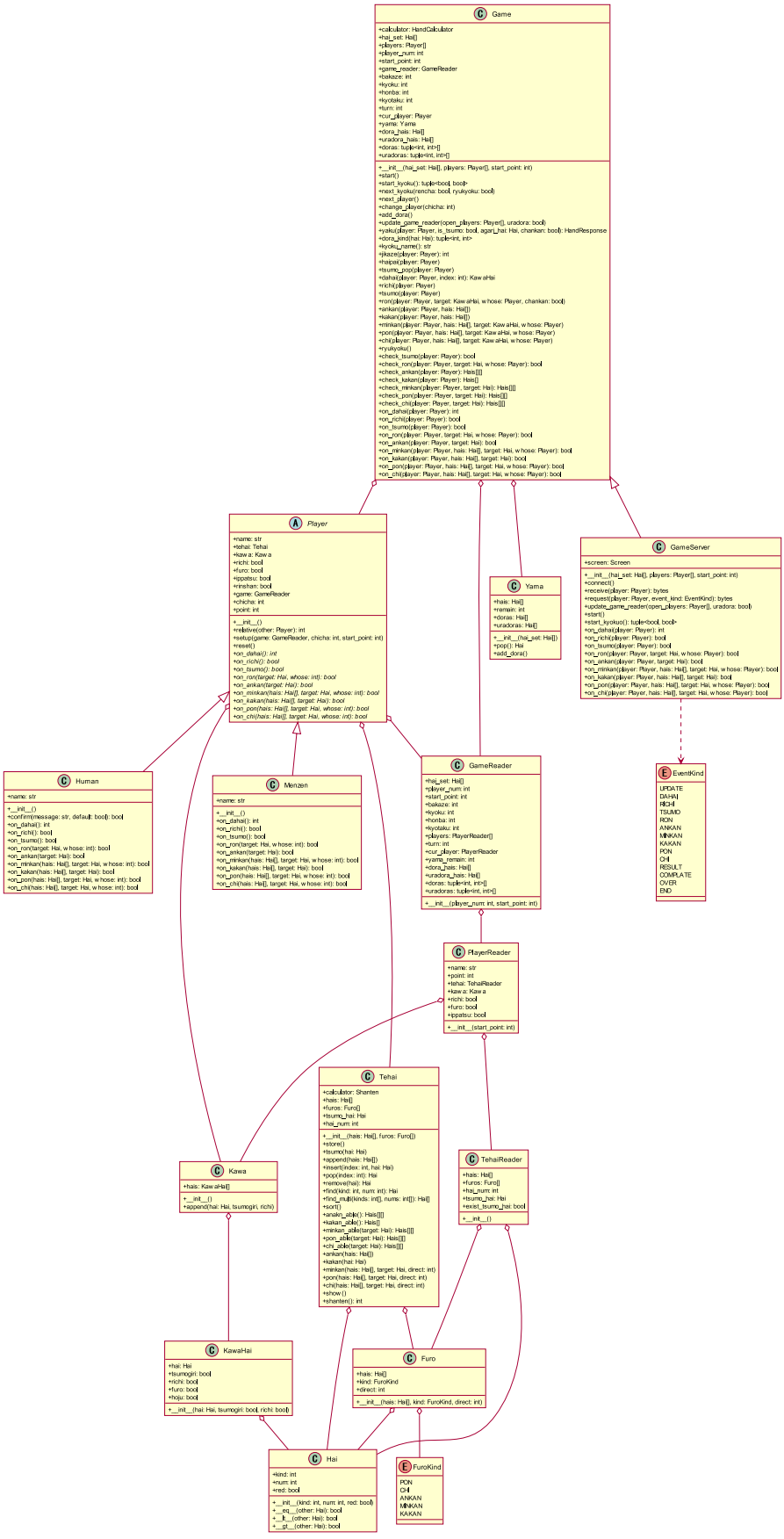
Game
+calculator: HandCalculator
+hai_set: Hai[]
+players: Player[]
+player_num: int
+start_point: int
+game_reader: GameReader
+bakaze: int
+kyoku: int
+honba: int
+kyotaku: int
+turn: int
+cur_player: Player
+yama: Yama
+dora_hais: Hai[]
+uradora_hais: Hai[]
+doras: tuple<int, int>[]
+uradoras: tuple<int, int>[]
+__init__(hai_set: Hai[], players: Player[], start_point: int)
+start()
+start_kyoku(): tuple<bool, bool>
+next_kyoku(renchа: bool, ryukyoku: bool)
+next_player()
+change_player(chicha: int)
+add_dora()
+update_game_reader(open_players: Player[], uradora: bool)
+yaku(player: Player, is_tsumo: bool, agari_hai: Hai, chankan: bool): HandResponse
+dora_kind(hai: Hai): tuple<int, int>
+kyoku_name(): str
+jikaze(player: Player): int
+haipai(player: Player)
+tsumo_pop(player: Player)
+daiha(player: Player, index: int): KawaHai
+richi(player: Player)
+tsumo(player: Player)
+ron(player: Player, target: KawaHai, whose: Player, chankan: bool)
+ankan(player: Player, hais: Hai[])
+kakan(player: Player, hais: Hai[])
+minkan(player: Player, hais: Hai[], target: KawaHai, whose: Player)
+pon(player: Player, hais: Hai[], target: KawaHai, whose: Player)
+chi(player: Player, hais: Hai[], target: KawaHai, whose: Player)
+ryukyoku()
+check_tsumo(player: Player): bool
+check_ron(player: Player, target: Hai, whose: Player): bool
+check_ankan(player: Player): Hais[][]
+check_kakan(player: Player): Hais[]
+check_minkan(player: Player, target: Hai): Hais[][]
+check_pon(player: Player, target: Hai): Hais[][]
+check_chi(player: Player, target: Hai): Hais[][]
+on_daha(player: Player): int
+on_richi(player: Player): bool
+on_tsumo(player: Player): bool
+on_ron(player: Player, target: Hai, whose: Player): bool
+on_ankan(player: Player, target: Hai): bool
+on_minkan(player: Player, hais: Hai[], target: Hai, whose: Player): bool
+on_kakan(player: Player, hais: Hai[], target: Hai): bool
+on_pon(player: Player, hais: Hai[], target: Hai, whose: Player): bool
+on_chi(player: Player, hais: Hai[], target: Hai, whose: Player): bool
Player
+name: str
+tehai: Tehai
+kawa: Kawa
+richi: bool
+furo: bool
+ippatsu: bool
+minhan: bool
+game: GameReader
+chicha: int
+point: int
+__init__()
+relative(other: Player): int
+setup(game: GameReader, chicha: int, start_point: int)
+reset()
+on_daha(): int
+on_richi(): bool
+on_tsumo(): bool
+on_ron(target: Hai, whose: int): bool
+on_ankan(target: Hai): bool
+on_minkan(hais: Hai[], target: Hai, whose: int): bool
+on_kakan(hais: Hai[], target: Hai): bool
+on_pon(hais: Hai[], target: Hai, whose: int): bool
+on_chi(hais: Hai[], target: Hai, whose: int): bool
Yama
+hais: Hai[]
+remain: int
+doras: Hai[]
+uradoras: Hai[]
+__init__(hai_set: Hai[])
+pop(): Hai
+add_dora()
GameServer
+screen: Screen
+__init__(hai_set: Hai[], players: Player[], start_point: int)
+connect()
+receive(player: Player): bytes
+request(player: Player, event_kind: EventKind): bytes
+update_game_reader(open_players: Player[], uradora: bool)
+start()
+start_kyoku(): tuple<bool, bool>
+on_daha(player: Player): int
+on_richi(player: Player): bool
+on_tsumo(player: Player): bool
+on_ron(player: Player, target: Hai, whose: Player): bool
+on_ankan(player: Player, target: Hai): bool
+on_minkan(player: Player, hais: Hai[], target: Hai, whose: Player): bool
+on_kakan(player: Player, hais: Hai[], target: Hai): bool
+on_pon(player: Player, hais: Hai[], target: Hai, whose: Player): bool
+on_chi(player: Player, hais: Hai[], target: Hai, whose: Player): bool
Human
+name: str
+__init__()
+confirm(message: str, default: bool): bool
+on_daha(): int
+on_richi(): bool
+on_tsumo(): bool
+on_ron(target: Hai, whose: int): bool
+on_ankan(target: Hai): bool
+on_minkan(hais: Hai[], target: Hai, whose: int): bool
+on_kakan(hais: Hai[], target: Hai): bool
+on_pon(hais: Hai[], target: Hai, whose: int): bool
+on_chi(hais: Hai[], target: Hai, whose: int): bool
Menzen
+name: str
+__init__()
+on_daha(): int
+on_richi(): bool
+on_tsumo(): bool
+on_ron(target: Hai, whose: int): bool
+on_ankan(target: Hai): bool
+on_minkan(hais: Hai[], target: Hai, whose: int): bool
+on_kakan(hais: Hai[], target: Hai): bool
+on_pon(hais: Hai[], target: Hai, whose: int): bool
+on_chi(hais: Hai[], target: Hai, whose: int): bool
GameReader
+hai_set: Hai[]
+player_num: int
+start_point: int
+bakaze: int
+kyoku: int
+honba: int
+kyotaku: int
+players: PlayerReader[]
+turn: int
+cur_player: PlayerReader
+yama_remain: int
+dora_hais: Hai[]
+uradora_hais: Hai[]
+doras: tuple<int, int>[]
+uradoras: tuple<int, int>[]
+__init__(player_num: int, start_point: int)
EventKind
UPDATE
DAHAI
RICHI
TSUMO
RON
ANKAN
MINKAN
KAKAN
PON
CHI
RESULT
COMPLATE
OVER
END
PlayerReader
+name: str
+point: int
+tehai: TehaiReader
+kawa: Kawa
+richi: bool
+furo: bool
+ippatsu: bool
+__init__(start_point: int)
Tehai
+calculator: Shanten
+hais: Hai[]
+furos: Furo[]
+tsumo_hai: Hai
+hai_num: int
+__init__(hais: Hai[], furos: Furo[])
+store()
+tsumo(hai: Hai)
+append(hais: Hai[])
+insert(index: int, hai: Hai)
+pop(index: int): Hai
+remove(hai): Hai
+find(kind: int, num: int): Hai
+find_multi(kinds: int[], nums: int[]): Hai[]
+sort()
+analio_atiki(): Hais[][]
+kakan_able(): Hais[]
+minkan_able(target: Hai): Hais[][]
+pon_able(target: Hai): Hais[][]
+chi_able(target: Hai): Hais[][]
+ankan(hais: Hai[])
+kakan(hai: Hai)
+minkan(hais: Hai[], target: Hai, direct: int)
+pon(hais: Hai[], target: Hai, direct: int)
+chi(hais: Hai[], target: Hai, direct: int)
+show()
+shanten(): int
Kawa
+hais: KawaHai[]
+__init__()
+append(hai: Hai, tsumogiri, richi)
TehaiReader
+hais: Hai[]
+furos: Furo[]
+hai_num: int
+exist_tsumo_hai: bool
+__init__()
KawaHai
+hai: Hai
+tsumogiri: bool
+richi: bool
+furo: bool
+koju: bool
+__init__(hai: Hai, tsumogiri: bool, richi: bool)
Furo
+hais: Hai[]
+kind: FuroKind
+direct: int
+__init__(hais: Hai[], kind: FuroKind, direct: int)
Hai
+kind: int
+num: int
+red: bool
+__init__(kind: int, num: int, red: bool)
+__eq__(other: Hai): bool
+__lt__(other: Hai): bool
+__gt__(other: Hai): bool
FuroKind
PON
CHI
ANKAN
MINKAN
KAKAN

図 20　クラス図

```
14      RICHI    = b"ric"
15      TSUMO    = b"tmo"
16      RON      = b"ron"
17      ANKAN    = b"aka"
18      MINKAN   = b"mka"
19      KAKAN    = b"kka"
20      PON      = b"pon"
21      CHI      = b"chi"
22      RESULT   = b"res"
23      COMPLETE = b"com"
24      OVER     = b"ovr"
25      END      = b"end"
26
27  # サーバーサイド
28  class GameServer(mj.Game):
29      def __init__(self, hai_set, players, start_point):
30          super().__init__(hai_set, players, start_point)
31
32          self.conns = {}
33          self.addrs = {}
34
35      # 接続が確率されるまで待機
36      def connect(self):
37          with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
38              # サーバーの設定
39              s.bind(("0.0.0.0", 50005))
40              s.listen(self.player_num)
41
42              num = 1
43
44              for i in range(self.player_num):
45                  player = self.players[i]
46
47                  if self.players[i].__class__.__name__ != "Human":
48                      continue
49
50                  # 接続待機
51                  print("No. {} Player: Waiting...".format(num))
52                  conn, addr = s.accept()
53
54                  # リストに追加
55                  self.conns[i] = conn
56                  self.addrs[i] = addr
57
58                  # 名前を受信
59                  player_name = self.receive(player)
60                  player.name = player_name.decode()
61
62                  print("No. {} Player: Connected".format(num))
63                  print("Name: {}".format(player.name))
64
65                  num += 1
66
67      # 受信
68      def receive(self, player):
69          conn = self.conns[player.chicha]
```

```
70          recv_data = b""
71
72          # データが終端に達するまで受信
73          while True:
74              data = conn.recv(4096)
75              recv_data += data
76
77              if recv_data[-3:] == EventKind.END:
78                  break
79
80          return recv_data[:-3]
81
82      # 選択を要求
83      def request(self, player, event_kind):
84          conn = self.conns[player.chicha]
85          conn.sendall(event_kind + EventKind.END)
86          return self.receive(player)
87
88      # ゲームリーダーを更新
89      def update_game_reader(self, open_players = [], uradora = False):
90          super().update_game_reader(open_players, uradora)
91
92          # 全てのクライアントにゲームリーダーを送信
93          for i in range(self.player_num):
94              player = self.players[i]
95
96              if player.__class__.__name__ != "Human":
97                  continue
98
99              send_data = pickle.dumps(self.players[i])
100             self.conns[i].sendall(EventKind.UPDATE + send_data + EventKind.END)
101
102         # 全てのクライアントから応答があるまで待機
103         for i in range(self.player_num):
104             player = self.players[i]
105
106             if player.__class__.__name__ != "Human":
107                 continue
108
109             self.receive(player)
110
111     # ゲーム開始
112     def start(self):
113         super().start()
114
115         # 終局
116         for i in range(self.player_num):
117             player = self.players[i]
118
119             if player.__class__.__name__ != "Human":
120                 continue
121
122             self.conns[i].sendall(EventKind.OVER + EventKind.END)
123
124     # 局開始
125     def start_kyoku(self):
```

```
126         renchan, ryukyoku = super().start_kyoku()
127 
128         # 終局
129         for i in range(self.player_num):
130             player = self.players[i]
131 
132             if player.__class__.__name__ != "Human":
133                 continue
134 
135             self.conns[i].sendall(EventKind.RESULT + EventKind.END)
136 
137         # 全てのクライアントから応答があるまで待機
138         for i in range(self.player_num):
139             player = self.players[i]
140 
141             if player.__class__.__name__ != "Human":
142                 continue
143 
144             self.receive(player)
145 
146         return renchan, ryukyoku
147 
148     # 選択
149     def on_dahai(self, player):
150         if player.__class__.__name__ == "Human":
151             data = self.request(player, EventKind.DAHAI)
152             return int.from_bytes(data, "big", signed=True)
153         else:
154             return super().on_dahai(player)
155 
156     # 立直するか
157     def on_richi(self, player):
158         if player.__class__.__name__ == "Human":
159             data = self.request(player, EventKind.RICHI)
160             return bool.from_bytes(data, "big", signed=True)
161         else:
162             return super().on_richi(player)
163 
164     # ツモ和了するか
165     def on_tsumo(self, player):
166         if player.__class__.__name__ == "Human":
167             data = self.request(player, EventKind.TSUMO)
168             return bool.from_bytes(data, "big", signed=True)
169         else:
170             return super().on_tsumo(player)
171 
172     # ロン和了するか
173     def on_ron(self, player, target, whose):
174         if player.__class__.__name__ == "Human":
175             data = self.request(player, EventKind.RON)
176             return bool.from_bytes(data, "big", signed=True)
177         else:
178             return super().on_ron(player, target, whose)
179 
180     # 暗槓するか
181     def on_ankan(self, player, target):
```

```
182         if player.__class__.__name__ == "Human":
183             data = self.request(player, EventKind.ANKAN)
184             return bool.from_bytes(data, "big", signed=True)
185         else:
186             return super().on_ankan(player, target)
187 
188     # 明槓するか
189     def on_minkan(self, player, hais, target, whose):
190         if player.__class__.__name__ == "Human":
191             data = self.request(player, EventKind.MINKAN)
192             return bool.from_bytes(data, "big", signed=True)
193         else:
194             return super().on_minkan(player, hais, target, whose)
195 
196     # 加槓するか
197     def on_kakan(self, player, target):
198         if player.__class__.__name__ == "Human":
199             data = self.request(player, EventKind.KAKAN)
200             return bool.from_bytes(data, "big", signed=True)
201         else:
202             return super().on_kakan(player, target)
203 
204     # ポンするか
205     def on_pon(self, player, hais, target, whose):
206         if player.__class__.__name__ == "Human":
207             data = self.request(player, EventKind.PON)
208             return bool.from_bytes(data, "big", signed=True)
209         else:
210             return super().on_pon(player, hais, target, whose)
211 
212     # チーするか
213     def on_chi(self, player, hais, target, whose):
214         if player.__class__.__name__ == "Human":
215             data = self.request(player, EventKind.CHI)
216             return bool.from_bytes(data, "big", signed=True)
217         else:
218             return super().on_chi(player, hais, target, whose)
219 
220 if __name__ == "__main__":
221     # 牌をセット
222     hai_set = []
223 
224     # 数牌
225     for i in range(3):
226         for j in range(1, 10):
227             hai_set.extend(mj.Hai(i, j, j == 5 and k == 3) for k in range(4))
228 
229     # 字牌
230     for i in range(1, 8):
231         hai_set.extend(mj.Hai(3, i) for j in range(4))
232 
233     # プレイヤー
234     players = [mp.Human(), mp.AI(), mp.Human(), mp.AI()]
235 
236     game = GameServer(hai_set, players, 25000)
237     game.connect()
```

```
238     game.start()
```

リスト 2　GameClient.py

```
1   import sys
2   import socket
3   import pickle
4
5   import mjgame.system as mj
6   import mjgame.players as mp
7   import mjgame.graphic as mg
8
9   from GameServer import EventKind
10
11  # 名前を入力
12  player_name = input("名前> ")
13
14  with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
15      # サーバーに接続し名前を送信
16      s.connect(("localhost", 50005))
17      s.sendall(player_name.encode() + EventKind.END)
18
19      while True:
20          recv_data = b""
21
22          # データを受信
23          while True:
24              data = s.recv(4096)
25              recv_data += data
26
27              if recv_data[-3:] == EventKind.END:
28                  break
29
30          # ヘッダと本文を切り離す
31          event_kind = recv_data[:3]
32          recv_data = recv_data[3:-3]
33
34          # ゲームリーダーのアップデート
35          if event_kind == EventKind.UPDATE:
36              s.sendall(EventKind.COMPLETE + EventKind.END)
37              player = pickle.loads(recv_data)
38
39              screen = mg.Screen(player.game, [player], player, "Mahjong")
40              screen.draw()
41
42          # 打牌
43          elif event_kind == EventKind.DAHAI:
44              ret = player.on_dahai()
45              s.sendall(ret.to_bytes(1, "big", signed=True) + EventKind.END)
46
47          # リーチ
48          elif event_kind == EventKind.RICHI:
49              ret = player.on_richi()
50              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
51
52          # ツモ
```

```
53          elif event_kind == EventKind.TSUMO:
54              ret = player.on_tsumo()
55              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
56
57          # ロン
58          elif event_kind == EventKind.RON:
59              ret = player.on_ron(None, None)
60              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
61
62          # 暗槓
63          elif event_kind == EventKind.ANKAN:
64              ret = player.on_ankan(None)
65              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
66
67          # 明槓
68          elif event_kind == EventKind.MINKAN:
69              ret = player.on_minkan(None, None, None)
70              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
71
72          # 加槓
73          elif event_kind == EventKind.KAKAN:
74              ret = player.on_kakan(None)
75              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
76
77          # ポン
78          elif event_kind == EventKind.PON:
79              ret = player.on_pon(None, None, None)
80              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
81
82          # チー
83          elif event_kind == EventKind.CHI:
84              ret = player.on_chi(None, None, None)
85              s.sendall(ret.to_bytes(1, "big") + EventKind.END)
86
87          # 終局
88          elif event_kind == EventKind.RESULT:
89              screen = mg.Screen(player.game, [player], player, "Mahjong")
90              screen.draw()
91
92              if input("Press Enter Key...") == "q":
93                  sys.exit()
94
95              s.sendall(EventKind.COMPLETE + EventKind.END)
96
97          # ゲーム終了
98          elif event_kind == EventKind.OVER:
99              break
```

リスト 3　mjgame/__init__.py

```
1 from .system import *
2 from .players import *
3 from .graphic import *
```

リスト 4　mjgame/system/__init__.py

```
from .core import *
from .player import *
from .game import *
```

リスト 5　mjgame/system/core.py

```
import enum

# 河
class Kawa():
    def __init__(self):
        self.hais = []

    # 追加
    def append(self, hai, tsumogiri=False, richi=False):
        self.hais.append(KawaHai(hai, tsumogiri, richi))

# 河の麻雀牌
class KawaHai():
    def __init__(self, hai, tsumogiri=False, richi=False):
        self.hai = hai
        self.tsumogiri = tsumogiri
        self.richi = richi
        self.furo = False
        self.hoju = False

# ゲームリーダー
class GameReader():
    def __init__(self, hai_set, player_num, start_point):
        self.hai_set = hai_set
        self.player_num = player_num
        self.start_point = start_point

        self.bakaze = 0
        self.kyoku = 0
        self.honba = 0
        self.kyotaku = 0

        self.players = [PlayerReader(i) for i in range(self.player_num)]
        self.turn = 0
        self.cur_player = self.players[self.turn]

        self.yama_remain = 0
        self.dora_hais = []
        self.uradora_hais = None
        self.doras = []
        self.uradoras = None

# プレイヤーリーダー
class PlayerReader():
    def __init__(self, chicha):
        self.name = ""
        self.chicha = chicha
        self.point = 0
        self.tehai = TehaiReader()
        self.kawa = Kawa()
```

```
51          self.richi = False
52          self.furo = False
53          self.ippatsu = False
54
55  # 手牌リーダー
56  class TehaiReader():
57      def __init__(self):
58          self.hais = None
59          self.furos = []
60          self.hai_num = 0
61          self.tsumo_hai = None
62          self.exist_tsumo_hai = False
63
64  # 副露
65  class Furo():
66      def __init__(self, hais, kind, direct=0):
67          self.hais = hais
68          self.kind = kind
69          self.direct = direct
70
71  # 副露の種類
72  class FuroKind(enum.Enum):
73      PON = enum.auto()
74      CHI = enum.auto()
75      ANKAN = enum.auto()
76      MINKAN = enum.auto()
77      KAKAN = enum.auto()
78
79  # 麻雀牌
80  class Hai():
81      """
82      kind:
83        0 ... 索子
84        1 ... 筒子
85        2 ... 萬子
86        3 ... 字牌
87
88      num:
89        1-9 ... 数字
90        or
91        1-7 ... 東～中
92      """
93
94      def __init__(self, kind, num, red=False):
95          self.kind = kind # 種類
96          self.num = num   # 数字
97          self.red = red   # 赤ドラかどうか
98
99          COLOR_NAME = ["s", "p", "m"]
100         JIHAI_NAME = ["Ton", "Nan", "Sha", "Pei", "Hak", "Hat", "Chu"]
101
102         # 名称
103         if self.kind <= 2:
104             self.name = "{}{}{}".format(
105                 COLOR_NAME[self.kind],
106                 self.num,
```

```
                "@" if self.red else ""
            )
        else:
            self.name = "{}{}".format(
                JIHAI_NAME[self.num - 1],
                "@" if self.red else ""
            )

    # 比較演算子
    def __eq__(self, other):
        return (self.kind, self.num, self.red) == (other.kind, other.num, other.red)

    def __lt__(self, other):
        return (self.kind, self.num, self.red) < (other.kind, other.num, other.red)

    def __gt__(self, other):
        return (self.kind, self.num, self.red) > (other.kind, other.num, other.red)
```

リスト 6　mjgame/system/game.py

```
import sys
import time
import random
import copy
import pickle

from .core import *
from .. import graphic as mg

from mahjong.hand_calculating.hand import HandCalculator
from mahjong.meld import Meld
from mahjong.hand_calculating.hand_config import HandConfig, OptionalRules
from mahjong.tile import TilesConverter
from mahjong.constants import EAST, SOUTH, WEST, NORTH

# ゲーム
class Game():
    def __init__(self, hai_set, players, start_point):
        seed = time.time()
        random.seed(seed)
        print("seed = {}".format(seed))

        self.calculator = HandCalculator()

        self.hai_set = hai_set
        self.players = players
        self.player_num = len(self.players)
        self.start_point = start_point

        self.game_reader = GameReader(self.hai_set, self.player_num, self.start_point)

        for i, player in enumerate(self.players):
            player.setup(self.game_reader, i, self.start_point)

        self.bakaze = 0  # 場風
        self.kyoku = 0   # 局
```

```
37          self.honba = 0   # 本場
38          self.kyotaku = 0 # 供託
39
40          # 番
41          self.turn = 0
42          self.cur_player = self.players[self.turn]
43
44          # 牌山
45          self.yama = Yama(self.hai_set)
46          self.dora_hais = [self.yama.doras[0]]
47          self.uradora_hais = [self.yama.uradoras[0]]
48          self.doras = [self.dora_kind(self.dora_hais[0])]
49          self.uradoras = [self.dora_kind(self.uradora_hais[0])]
50
51      # ゲーム開始
52      def start(self):
53          while self.bakaze <= 1:
54              renchan, ryukyoku = self.start_kyoku()
55              self.next_kyoku(renchan, ryukyoku)
56
57      # 局開始
58      def start_kyoku(self):
59          # コンソール表示
60          print("{} {}本場 供託{}".format(self.kyoku_name(), self.honba, self.kyotaku))
61
62          # 配牌
63          for player in self.players:
64              self.haipai(player)
65
66          while self.yama.remain > 0:
67              # ツモ
68              self.tsumo_pop(self.cur_player)
69
70              # コンソール表示
71              print("{} ({}) [残り{}]".format(self.cur_player.name, self.cur_player.point,
    self.yama.remain))
72              self.cur_player.tehai.show()
73
74              # ツモ判定
75              if self.check_tsumo(self.cur_player) and self.on_tsumo(self.cur_player):
76                  self.tsumo(self.cur_player)
77                  return self.jikaze(self.cur_player) == 0, False
78
79              cont = False
80
81              # 暗槓
82              for cur_hais in self.check_ankan(self.cur_player):
83                  if self.on_ankan(self.cur_player, cur_hais):
84                      self.ankan(self.cur_player, cur_hais)
85                      cont = True
86                      break
87
88              if cont:
89                  continue
90
91              # 加槓
```

```
92              for cur_hai in self.check_kakan(self.cur_player):
93                  if self.on_kakan(self.cur_player, cur_hai):
94                      # 槍槓判定
95                      for player in self.players:
96                          # 自身は判定しない
97                          if player == self.cur_player:
98                              continue
99
100                         if self.check_ron(player, cur_hai, self.cur_player) and self.on_ron
    (player, cur_hai.hai, self.cur_player):
101                             self.ron(player, cur_hai, self.cur_player, True)
102
103                             ron = True
104                             if self.jikaze(player) == 0:
105                                 renchan = True
106
107                     if ron:
108                         return renchan, False
109
110                     self.kakan(self.cur_player, cur_hai)
111                     cont = True
112                     break
113
114             if cont:
115                 continue
116
117             while True:
118                 # 打牌
119                 if self.cur_player.richi:
120                     index = -1
121                 else:
122                     index = self.on_dahai(self.cur_player)
123
124                 check_hai = self.dahai(self.cur_player, index)
125
126                 # 立直
127                 if not self.cur_player.richi and not self.cur_player.furo and self.
    cur_player.tehai.shanten() == 0:
128                     if self.on_richi(self.cur_player):
129                         self.richi(self.cur_player)
130
131                 ron = False
132                 renchan = False
133                 minkan = False
134                 furo = False
135
136                 # ロン判定
137                 for player in self.players:
138                     # 自身は判定しない
139                     if player == self.cur_player:
140                         continue
141
142                     if self.check_ron(player, check_hai.hai, self.cur_player) and self.
    on_ron(player, check_hai.hai, self.cur_player):
143                         self.ron(player, check_hai, self.cur_player)
144
```

```
145                         ron = True
146                         if self.jikaze(player) == 0:
147                             renchan = True
148
149                 if ron:
150                     return renchan, False
151
152                 # 副露判定
153                 for player in self.players:
154                     # 自身は判定しない
155                     if player == self.cur_player:
156                         continue
157
158                     # 明槓
159                     for cur_hais in self.check_minkan(player, check_hai.hai):
160                         if self.on_minkan(player, cur_hais, check_hai.hai, self.cur_player)
    :
161                             self.minkan(player, cur_hais, check_hai, self.cur_player)
162                             minkan = True
163                             break
164
165                     if minkan:
166                         break
167
168                     # ポン
169                     for cur_hais in self.check_pon(player, check_hai.hai):
170                         if self.on_pon(player, cur_hais, check_hai.hai, self.cur_player):
171                             self.pon(player, cur_hais, check_hai, self.cur_player)
172                             furo = True
173                             break
174
175                     if furo:
176                         break
177
178                     # チー
179                     if self.player_num >= 4 and self.cur_player.relative(player) == 1:
180                         for cur_hais in self.check_chi(player, check_hai.hai):
181                             if self.on_chi(player, cur_hais, check_hai.hai, self.cur_player
    ):
182                                 self.chi(player, cur_hais, check_hai, self.cur_player)
183                                 furo = True
184                                 break
185
186                     if furo:
187                         break
188
189                 if minkan or not furo:
190                     break
191
192             if not minkan:
193                 self.next_player()
194
195         self.ryukyoku()
196         return self.players[self.kyoku].tehai.shanten() == 0, True
197
198     # 次の局へ
```

```
199     def next_kyoku(self, renchan, ryukyoku):
200         # 局を更新
201         if not renchan:
202             self.kyoku += 1
203             if self.kyoku >= self.player_num:
204                 self.kyoku = 0
205                 self.bakaze += 1
206 
207         # 本場
208         if renchan or ryukyoku:
209             self.honba += 1
210         else:
211             self.honba = 0
212 
213         # 供託
214         if ryukyoku:
215             for player in self.players:
216                 if player.richi:
217                     self.kyotaku += 1
218         else:
219             self.kyotaku = 0
220 
221         # リセット
222         self.change_player(self.kyoku)
223         self.yama = Yama(self.hai_set)
224         self.dora_hais = [self.yama.doras[0]]
225         self.uradora_hais = [self.yama.uradoras[0]]
226         self.doras = [self.dora_kind(self.dora_hais[0])]
227         self.uradoras = [self.dora_kind(self.uradora_hais[0])]
228 
229         for player in self.players:
230             player.reset()
231 
232         self.update_game_reader()
233 
234     # 次のプレイヤーへ
235     def next_player(self):
236         self.change_player((self.turn + 1) % self.player_num)
237 
238     # プレイヤーのツモ順を変更
239     def change_player(self, chicha):
240         self.turn = chicha
241         self.cur_player = self.players[self.turn]
242         self.update_game_reader()
243 
244     # ドラ追加
245     def add_dora(self):
246         self.yama.add_dora()
247         self.dora_hais.append(self.yama.doras[-1])
248         self.uradora_hais.append(self.yama.uradoras[-1])
249         self.doras.append(self.dora_kind(self.dora_hais[-1]))
250         self.uradoras.append(self.dora_kind(self.uradora_hais[-1]))
251         self.update_game_reader()
252 
253     # ゲームリーダーを更新
254     def update_game_reader(self, open_players = [], uradora = False):
```

```
255         self.game_reader.bakaze = self.bakaze
256         self.game_reader.kyoku = self.kyoku
257         self.game_reader.honba = self.honba
258         self.game_reader.kyotaku = self.kyotaku
259 
260         self.game_reader.turn = self.turn
261         self.game_reader.cur_player = self.game_reader.players[self.game_reader.turn]
262 
263         self.game_reader.yama_remain = self.yama.remain
264         self.game_reader.dora_hais = self.dora_hais
265         self.game_reader.doras = self.doras
266 
267         if uradora:
268             self.game_reader.uradora_hais = self.uradora_hais
269             self.game_reader.uradoras = self.uradoras
270         else:
271             self.game_reader.uradora_hais = None
272             self.game_reader.uradoras = None
273 
274         for i in range(self.player_num):
275             player = self.game_reader.players[i]
276             player_org = self.players[i]
277 
278             player.name = player_org.name
279             player.point = player_org.point
280 
281             if player_org in open_players:
282                 player.tehai.hais = player_org.tehai.hais
283                 player.tehai.tsumo_hai = player_org.tehai.tsumo_hai
284             else:
285                 player.tehai.hais = None
286                 player.tehai.tsumo_hai = None
287 
288             player.tehai.furos = player_org.tehai.furos
289             player.tehai.hai_num = player_org.tehai.hai_num
290             player.tehai.exist_tsumo_hai = player_org.tehai.tsumo_hai is not None
291             player.kawa = player_org.kawa
292             player.richi = player_org.richi
293             player.furo = player_org.furo
294             player.ippatsu = player_org.ippatsu
295 
296     # 役
297     def yaku(self, player, is_tsumo, agari_hai=None, chankan=False):
298         # 手牌
299         tile_strs = [""] * 4
300         win_tile_strs = [""] * 4
301 
302         for hai in player.tehai.hais:
303             tile_strs[hai.kind] += "r" if hai.red else str(hai.num)
304 
305         for furo in player.tehai.furos:
306             for hai in furo.hais:
307                 tile_strs[hai.kind] += "r" if hai.red else str(hai.num)
308 
309             if furo.kind == FuroKind.ANKAN or furo.kind == FuroKind.MINKAN or furo.kind ==
    FuroKind.KAKAN:
```

```
310                 tile_strs[furo.hais[0].kind] = tile_strs[furo.hais[0].kind][:-1]
311
312         if is_tsumo:
313             hai = player.tehai.tsumo_hai
314             tile_strs[hai.kind] += "r" if hai.red else str(hai.num)
315             win_tile_strs[hai.kind] += "r" if hai.red else str(hai.num)
316         else:
317             tile_strs[agari_hai.kind] += "r" if agari_hai.red else str(agari_hai.num)
318             win_tile_strs[agari_hai.kind] += "r" if agari_hai.red else str(agari_hai.num)
319
320         tiles = TilesConverter.string_to_136_array(tile_strs[0], tile_strs[1], tile_strs
    [2], tile_strs[3], True)
321         win_tile = TilesConverter.string_to_136_array(win_tile_strs[0], win_tile_strs[1],
    win_tile_strs[2], win_tile_strs[3], True)[0]
322
323         # 副露
324         FURO_MELD = {
325             FuroKind.PON: Meld.PON,
326             FuroKind.CHI: Meld.CHI,
327             FuroKind.ANKAN: Meld.KAN,
328             FuroKind.MINKAN: Meld.KAN,
329             FuroKind.KAKAN: Meld.CHANKAN
330         }
331
332         melds = []
333
334         for furo in player.tehai.furos:
335             furo_strs = [""] * 4
336
337             for hai in furo.hais:
338                 furo_strs[hai.kind] += "r" if hai.red else str(hai.num)
339
340             meld_tiles = TilesConverter.string_to_136_array(furo_strs[0], furo_strs[1],
    furo_strs[2], furo_strs[3], True)
341             melds.append(Meld(FURO_MELD[furo.kind], meld_tiles, furo.kind != FuroKind.ANKAN
    ))
342
343         # ドラ
344         dora_indicators = []
345
346         for hai in self.dora_hais:
347             dora_strs = [""] * 4
348             dora_strs[hai.kind] += "r" if hai.red else str(hai.num)
349
350             dora_tile = TilesConverter.string_to_136_array(dora_strs[0], dora_strs[1],
    dora_strs[2], dora_strs[3], True)[0]
351             dora_indicators.append(dora_tile)
352
353         if player.richi:
354             for hai in self.uradora_hais:
355                 dora_strs = [""] * 4
356                 dora_strs[hai.kind] += "r" if hai.red else str(hai.num)
357
358                 dora_tile = TilesConverter.string_to_136_array(dora_strs[0], dora_strs[1],
    dora_strs[2], dora_strs[3], True)[0]
359                 dora_indicators.append(dora_tile)
```

```
360
361         # 設定
362         KAZE_WIND = [EAST, SOUTH, WEST, NORTH]
363
364         config = HandConfig(
365             is_tsumo=is_tsumo,
366             is_riichi=player.richi,
367             is_ippatsu=player.ippatsu,
368             is_rinshan=player.rinshan,
369             is_chankan=chankan,
370             is_haitei=agari_hai is None and self.yama.remain == 0,
371             is_houtei=agari_hai is not None and self.yama.remain == 0,
372             is_daburu_riichi=len(player.kawa.hais) > 0 and player.kawa.hais[0].richi,
373             is_tenhou=agari_hai is None and self.jikaze(player) == 0 and len(player.kawa.
    hais) == 0,
374             is_renhou=agari_hai is not None and len(player.kawa.hais) == 0,
375             is_chiihou=agari_hai is None and self.jikaze(player) != 0 and len(player.kawa.
    hais) == 0,
376             player_wind=KAZE_WIND[self.jikaze(player)],
377             round_wind=KAZE_WIND[self.bakaze],
378             options=OptionalRules(has_aka_dora=True)
379         )
380
381         return self.calculator.estimate_hand_value(tiles, win_tile, melds, dora_indicators,
     config)
382
383     # ドラ表示牌に対応するドラ
384     def dora_kind(self, hai):
385         # 数牌
386         if hai.kind <= 2:
387             next_num = hai.num
388
389             while True:
390                 next_num += 1
391                 if (next_num > 9):
392                     next_num = 1
393
394                 if Hai(hai.kind, next_num) in self.hai_set or Hai(hai.kind, next_num, True)
     in self.hai_set:
395                     return (hai.kind, next_num)
396
397         # 東南西北
398         elif 1 <= hai.num <= 4:
399             next_num = hai.num + 1
400             if (next_num > 4):
401                 next_num = 1
402
403             return (hai.kind, next_num)
404
405         # 白發中
406         elif 5 <= hai.num <= 7:
407             next_num = hai.num + 1
408             if (next_num > 7):
409                 next_num = 5
410
411             return (hai.kind, next_num)
```

```
412
413     # 局を表す文字列
414     def kyoku_name(self):
415         KAZE_NAME = ["東", "南", "西", "北"]
416         return "{}{}局".format(KAZE_NAME[self.bakaze], self.kyoku + 1)
417
418     # 自風
419     def jikaze(self, player):
420         return (player.chicha - self.kyoku) % self.player_num
421
422     # 配牌
423     def haipai(self, player):
424         player.tehai.append([self.yama.pop() for i in range(13)])
425         player.tehai.sort()
426         self.update_game_reader()
427
428     # ツモ
429     def tsumo_pop(self, player):
430         player.tehai.tsumo(self.yama.pop())
431         self.update_game_reader()
432
433     # 打牌
434     def dahai(self, player, index):
435         tsumogiri = (index == -1 or index == player.tehai.hai_num - 1)
436         player.kawa.append(player.tehai.pop(index), tsumogiri)
437         player.tehai.sort()
438
439         player.ippatsu = False
440         player.rinshan = False
441
442         self.update_game_reader()
443         return player.kawa.hais[-1]
444
445     # リーチ
446     def richi(self, player):
447         player.richi = True
448         player.ippatsu = True
449         player.kawa.hais[-1].richi = True
450         self.update_game_reader()
451
452     # ツモ
453     def tsumo(self, player):
454         yaku = self.yaku(player, True)
455
456         # 点数移動
457         for cur_player in self.players:
458             if cur_player == player:
459                 continue
460
461             change_point = yaku.cost["main" if self.jikaze(cur_player) == 0 else "
    additional"] + self.honba * 100
462             player.point += change_point
463             cur_player.point -= change_point
464
465             # リーチ棒
466             if cur_player.richi:
```

```
467                 player.point += 1000
468                 cur_player.point -= 1000
469
470         # 供託
471         player.point += self.kyotaku * 1000
472
473         # 表示
474         print("{}：ツモ".format(player.name))
475         print(yaku.yaku)
476         print("{}翻 {}符".format(yaku.han, yaku.fu))
477
478         self.update_game_reader([player], player.richi)
479
480     # ロン
481     def ron(self, player, target, whose, chankan = False):
482         if chankan:
483             hai = target
484         else:
485             hai = target.hai
486             target.hoju = True
487
488         player.tehai.tsumo(hai)
489         yaku = self.yaku(player, False, hai, chankan)
490
491         # 点数移動
492         change_point = yaku.cost["main"] + self.honba * 300
493         player.point += change_point
494         whose.point -= change_point
495
496         # リーチ棒
497         for cur_player in self.players:
498             if cur_player != player and cur_player.richi:
499                 player.point += 1000
500                 cur_player.point -= 1000
501
502         # 供託
503         player.point += self.kyotaku * 1000
504
505         # 表示
506         print("{}→{}：ロン".format(whose.name, player.name))
507         print(yaku.yaku)
508         print("{}翻 {}符".format(yaku.han, yaku.fu))
509
510         self.update_game_reader([player], player.richi)
511
512     # 暗槓
513     def ankan(self, player, hais):
514         player.tehai.ankan(hais)
515         player.rinshan = True
516
517         self.add_dora()
518
519         for player in self.players:
520             player.ippatsu = False
521
522         self.update_game_reader()
```

```
523
524     # 加槓
525     def kakan(self, player, hai):
526         player.tehai.kakan(hai)
527         player.rinshan = True
528
529         self.add_dora()
530
531         for player in self.players:
532             player.ippatsu = False
533
534         self.update_game_reader()
535
536     # 明槓
537     def minkan(self, player, hais, target, whose):
538         player.tehai.minkan(hais, target.hai, player.relative(whose))
539         player.furo = True
540         player.rinshan = True
541         target.furo = True
542
543         self.change_player(player.chicha)
544         self.add_dora()
545
546         for player in self.players:
547             player.ippatsu = False
548
549         self.update_game_reader()
550
551     # ポン
552     def pon(self, player, hais, target, whose):
553         player.tehai.pon(hais, target.hai, player.relative(whose))
554         player.furo = True
555         target.furo = True
556
557         self.change_player(player.chicha)
558
559         for player in self.players:
560             player.ippatsu = False
561
562         self.update_game_reader()
563
564     # チー
565     def chi(self, player, hais, target, whose):
566         player.tehai.chi(hais, target.hai, player.relative(whose))
567         player.furo = True
568         target.furo = True
569
570         self.change_player(player.chicha)
571
572         for player in self.players:
573             player.ippatsu = False
574
575         self.update_game_reader()
576
577     # 流局
578     def ryukyoku(self):
```

```
579         open_players = []
580 
581         tenpai_cnt = 0
582 
583         for player in self.players:
584             if player.tehai.shanten() == 0:
585                 tenpai_cnt += 1
586 
587         for player in self.players:
588             # 点数移動
589             if tenpai_cnt != 0 and tenpai_cnt != self.player_num:
590                 if player.tehai.shanten() == 0:
591                     player.point += int(3000 / tenpai_cnt)
592                 else:
593                     player.point -= int(3000 / (self.player_num - tenpai_cnt))
594 
595             # 供託
596             if player.richi:
597                 player.point -= 1000
598 
599             if player.tehai.shanten() == 0:
600                 print("{}:テンパイ".format(player.name))
601                 open_players.append(player)
602             else:
603                 print("{}:ノーテン".format(player.name))
604 
605         self.update_game_reader(open_players)
606 
607     # ツモチェック
608     def check_tsumo(self, player):
609         if player.tehai.shanten() != -1:
610             return False
611 
612         yaku = self.yaku(player, True)
613         return yaku.cost is not None
614 
615     # ロンチェック
616     def check_ron(self, player, target, whose):
617         player.tehai.tsumo(target)
618         cur_shanten = player.tehai.shanten()
619         player.tehai.pop()
620 
621         if cur_shanten != -1:
622             return False
623 
624         yaku = self.yaku(player, False, target)
625         return yaku.cost is not None
626 
627     # 暗槓チェック
628     def check_ankan(self, player):
629         return player.tehai.ankan_able()
630 
631     # 加槓チェック
632     def check_kakan(self, player):
633         return player.tehai.kakan_able()
634 
```

```
635     # 明槓チェック
636     def check_minkan(self, player, target):
637         if player.richi:
638             return []
639 
640         return player.tehai.minkan_able(target)
641 
642     # ポンチェック
643     def check_pon(self, player, target):
644         if player.richi:
645             return []
646 
647         return player.tehai.pon_able(target)
648 
649     # チーチェック
650     def check_chi(self, player, target):
651         if player.richi:
652             return []
653 
654         return player.tehai.chi_able(target)
655 
656     # 選択
657     def on_dahai(self, player):
658         return player.on_dahai()
659 
660     # 立直するか
661     def on_richi(self, player):
662         return player.on_richi()
663 
664     # ツモ和了するか
665     def on_tsumo(self, player):
666         return player.on_tsumo()
667 
668     # ロン和了するか
669     def on_ron(self, player, target, whose):
670         return player.on_ron(target, whose.chicha)
671 
672     # 暗槓するか
673     def on_ankan(self, player, target):
674         return player.on_ankan(target)
675 
676     # 明槓するか
677     def on_minkan(self, player, hais, target, whose):
678         return player.on_minkan(hais, target, whose.chicha)
679 
680     # 加槓するか
681     def on_kakan(self, player, target):
682         return player.on_kakan(target)
683 
684     # ポンするか
685     def on_pon(self, player, hais, target, whose):
686         return player.on_pon(hais, target, whose.chicha)
687 
688     # チーするか
689     def on_chi(self, player, hais, target, whose):
690         return player.on_chi(hais, target, whose.chicha)
```

```

# 山
class Yama():
    def __init__(self, hai_set):
        self.hais = hai_set[:]
        random.shuffle(self.hais)
        self.remain = len(self.hais) - 14
        self.doras = []
        self.uradoras = []
        self.add_dora()

    # 取り出し
    def pop(self):
        self.remain -= 1
        return self.hais.pop()

    # ドラを増やす
    def add_dora(self):
        self.doras.append(self.hais[len(self.doras) * 2])
        self.uradoras.append(self.hais[len(self.uradoras) * 2 + 1])
```

リスト 7　mjgame/system/player.py

```
from abc import ABCMeta, abstractmethod
from .core import *
from .tehai import Tehai

# プレイヤー
class Player(metaclass=ABCMeta):
    def __init__(self):
        self.name = ""
        self.reset()

    # 下家・対面・上家
    def relative(self, other):
        return (other.chicha - self.chicha) % 4

    # 初期設定
    def setup(self, game, chicha, start_point):
        self.game = game
        self.chicha = chicha
        self.point = start_point

    # 手牌・河をリセット
    def reset(self):
        self.tehai = Tehai()
        self.kawa = Kawa()
        self.richi = False
        self.furo = False
        self.ippatsu = False
        self.rinshan = False

    # 選択
    @abstractmethod
    def on_dahai(self):
        pass
```

```
34
35      # 立直するか
36      @abstractmethod
37      def on_richi(self):
38          pass
39
40      # ツモ和了するか
41      @abstractmethod
42      def on_tsumo(self):
43          pass
44
45      # ロン和了するか
46      @abstractmethod
47      def on_ron(self, target, whose):
48          pass
49
50      # 暗槓するか
51      @abstractmethod
52      def on_ankan(self, target):
53          pass
54
55      # 明槓するか
56      @abstractmethod
57      def on_minkan(self, hais, target, whose):
58          pass
59
60      # 加槓するか
61      @abstractmethod
62      def on_kakan(self, target):
63          pass
64
65      # ポンするか
66      @abstractmethod
67      def on_pon(self, hais, target, whose):
68          pass
69
70      # チーするか
71      @abstractmethod
72      def on_chi(self, hais, target, whose):
73          pass
```

リスト 8　mjgame/system/tehai.py

```
1   import copy
2   import itertools
3   import collections
4   from .core import *
5
6   from mahjong.shanten import Shanten
7   from mahjong.tile import TilesConverter
8
9   # 手牌
10  class Tehai():
11      def __init__(self, hais=[], furos=[]):
12          self.calculator = Shanten()
13          self.hais = hais[:]
```

```
14          self.furos = furos[:]
15          self.tsumo_hai = None
16          self.hai_num = len(self.hais)
17
18      # ツモ牌を手牌に格納
19      def store(self):
20          if self.tsumo_hai is not None:
21              self.hais.append(self.tsumo_hai)
22              self.tsumo_hai = None
23
24      # ツモ
25      def tsumo(self, hai):
26          self.store()
27          self.tsumo_hai = hai
28          self.hai_num = len(self.hais) + 1
29
30      # 追加
31      def append(self, hais):
32          self.store()
33          for hai in hais:
34              self.hais.append(hai)
35          self.hai_num = len(self.hais)
36
37      # 挿入
38      def insert(self, index, hai):
39          self.store()
40          self.hais.insert(index, hai)
41          self.hai_num = len(self.hais)
42
43      # 番号で取り出し
44      def pop(self, index=-1):
45          self.store()
46          pop_hai = self.hais.pop(index)
47          self.hai_num = len(self.hais)
48          return pop_hai
49
50      # 牌を指定して取り出し
51      def remove(self, hai):
52          self.store()
53          self.hais.remove(hai)
54          self.hai_num = len(self.hais)
55          return hai
56
57      # 牌の種類を指定して検索
58      def find(self, kind, num):
59          for hai in self.hais + [self.tsumo_hai]:
60              if hai is not None and hai.kind == kind and hai.num == num:
61                  return hai
62          return None
63
64      # 複数の牌を検索
65      def find_multi(self, kinds, nums):
66          if len(kinds) != len(nums):
67              return None
68
69          find_num = len(kinds)
```

```
70          found_hais = []
71
72          for hai in self.hais + [self.tsumo_hai]:
73              if hai is None:
74                  continue
75
76              for kind, num in zip(kinds, nums):
77                  if hai.kind == kind and hai.num == num:
78                      found_hais.append(hai)
79                      kinds.remove(kind)
80                      nums.remove(num)
81                      break
82
83          if len(found_hais) == find_num:
84              return found_hais
85          else:
86              return None
87
88      # 並べ替え
89      def sort(self):
90          self.store()
91          self.hais.sort()
92
93      # 暗槓可能な牌
94      def ankan_able(self):
95          return_hais = []
96
97          for hai in self.hais + [self.tsumo_hai]:
98              for return_hai in return_hais:
99                  if hai.kind == return_hai[0].kind and hai.num == return_hai[0].num:
100                     break
101             else:
102                 found_hais = self.find_multi([hai.kind for i in range(4)], [hai.num for i
    in range(4)])
103
104                 if found_hais is not None:
105                     return_hais.append(found_hais)
106
107         return return_hais
108
109     # 加槓可能な牌
110     def kakan_able(self):
111         return_hais = []
112
113         for furo in self.furos:
114             if furo.kind == FuroKind.PON:
115                 for hai in self.hais + [self.tsumo_hai]:
116                     # 明刻と同じ牌だったら
117                     if furo.hais[0].kind == hai.kind and furo.hais[0].num == hai.num:
118                         return_hais.append(hai)
119                         break
120
121         return return_hais
122
123     # 明槓可能な牌
124     def minkan_able(self, target):
```

```
125         found_hais = self.find_multi([target.kind for i in range(3)], [target.num for i in
    range(3)])
126 
127         if found_hais is None:
128             return []
129         else:
130             return [found_hais]
131 
132     # ポン可能な牌
133     def pon_able(self, target):
134         found_hais = self.find_multi([target.kind for i in range(2)], [target.num for i in
    range(2)])
135 
136         if found_hais is None:
137             return []
138         else:
139             return [found_hais]
140 
141     # チー可能な牌
142     def chi_able(self, target):
143         if target.kind == 3:
144             return []
145 
146         return_hais = []
147 
148         for i in range(-2, 1):
149             kinds = []
150             nums = []
151 
152             for j in range(i, i + 3):
153                 if j == 0:
154                     continue
155 
156                 kinds.append(target.kind)
157                 nums.append(target.num + j)
158 
159             found_hais = self.find_multi(kinds, nums)
160 
161             if found_hais is not None:
162                 return_hais.append(found_hais)
163 
164         return return_hais
165 
166     # 暗槓
167     def ankan(self, hais):
168         append_hais = [self.remove(hai) for hai in hais]
169         self.furos.append(Furo(append_hais, FuroKind.ANKAN))
170         self.sort()
171 
172     # 加槓
173     def kakan(self, hai):
174         for furo in self.furos:
175             if furo.kind == FuroKind.PON:
176                 # 明刻と同じ牌だったら
177                 if furo.hais[0].kind == hai.kind and furo.hais[0].num == hai.num:
178                     furo.kind = FuroKind.KAKAN
```

```
                    furo.hais.append(self.remove(hai))

    # 明槓
    def minkan(self, hais, target, direct):
        append_hais = [self.remove(hai) for hai in hais]
        append_hais.insert(int((direct - 1) * 1.5), target)
        self.furos.append(Furo(append_hais, FuroKind.MINKAN, direct))

    # ポン
    def pon(self, hais, target, direct):
        append_hais = [self.remove(hai) for hai in hais]
        append_hais.insert(direct - 1, target)
        self.furos.append(Furo(append_hais, FuroKind.PON, direct))

    # チー
    def chi(self, hais, target, direct):
        append_hais = [self.remove(hai) for hai in hais]
        append_hais.insert(direct - 1, target)
        self.furos.append(Furo(append_hais, FuroKind.CHI, direct))

    # 表示
    def show(self):
        for hai in self.hais:
            print(format(hai.name, "<4s"), end="")

        if self.tsumo_hai is not None:
            print(" {}".format(self.tsumo_hai.name))
        else:
            print()

        for j in range(len(self.hais)):
            print(format(j, "<4d"), end="")

        if self.tsumo_hai is not None:
            print(" {}".format(j + 1))
        else:
            print()

    # シャンテン数
    def shanten(self):
        tile_strs = [""] * 4

        for hai in self.hais:
            tile_strs[hai.kind] += str(hai.num)

        if self.tsumo_hai is not None:
            tile_strs[self.tsumo_hai.kind] += str(self.tsumo_hai.num)

        tiles = TilesConverter.string_to_34_array(tile_strs[0], tile_strs[1], tile_strs[2],
 tile_strs[3])

        return self.calculator.calculate_shanten(tiles)
```

リスト 9　mjgame/players/__init__.py

```
from .human import *
```

```
2 from .ai import *
```

リスト 10　mjgame/players/human.py

```
1  import sys
2  from .. import system as mj
3
4  # 人間
5  class Human(mj.Player):
6      def __init__(self):
7          super().__init__()
8          self.name = "Human"
9
10     # 確認メッセージを表示
11     def confirm(self, message, default=True):
12         while True:
13             select_input = input("{} [{}]> ".format(message, "Y/n" if default else "y/N"))
14
15             if select_input == "":
16                 return default
17
18             elif select_input == "Y" or select_input == "y":
19                 return True
20
21             elif select_input == "N" or select_input == "n":
22                 return False
23
24     # 選択
25     def on_dahai(self):
26         # 入力
27         while True:
28             select_input = input("> ")
29
30             if select_input == "q":
31                 sys.exit()
32
33             # ツモ切り
34             elif select_input == "":
35                 return -1
36
37             elif select_input.isdecimal() and 0 <= int(select_input) <= self.tehai.hai_num:
38                 break
39
40         return int(select_input)
41
42     # 立直
43     def on_richi(self):
44         return self.confirm("立直する？", False)
45
46     # ツモ和了
47     def on_tsumo(self):
48         return self.confirm("ツモる？", True)
49
50     # ロン和了
51     def on_ron(self, target, whose):
52         return self.confirm("ロンする？", True)
```

```
53
54      # 暗槓
55      def on_ankan(self, target):
56          return self.confirm("暗槓する？", False)
57
58      # 明槓
59      def on_minkan(self, hais, target, whose):
60          return self.confirm("明槓する？", False)
61
62      # 加槓
63      def on_kakan(self, target):
64          return self.confirm("加槓する？", False)
65
66      # ポン
67      def on_pon(self, hais, target, whose):
68          return self.confirm("ポンする？", False)
69
70      # チー
71      def on_chi(self, hais, target, whose):
72          return self.confirm("チーする？", False)
```

リスト 11　mjgame/players/ai.py

```
1   import copy
2   from .. import player
3
4   # 手なりAI
5   class Tenari(player.Player):
6       def __init__(self):
7           super().__init__()
8           self.name = "Tenari"
9
10      # 選択
11      def on_dahai(self):
12          select_index = -1
13          effect_max = 0
14          cur_shanten = self.tehai.shanten()
15
16          # 残っている牌
17          remain_hai = self.game.hai_set[:]
18
19          # 自身の手牌
20          for hai in self.tehai.hais:
21              remain_hai.remove(hai)
22
23          for player in self.game.players:
24              # 副露
25              for furo in player.tehai.furos:
26                  for hai in furo.hais:
27                      remain_hai.remove(hai)
28
29              # 河
30              for kawa_hai in player.kawa.hais:
31                  if not kawa_hai.furo:
32                      remain_hai.remove(kawa_hai.hai)
33
```

```
34          # ドラ
35          for dora in self.game.dora_hais:
36              remain_hai.remove(dora)
37
38          for i in range(self.tehai.hai_num):
39              # 1枚ずつ切ってみる
40              pop_hai = self.tehai.pop(i)
41
42              # シャンテン数が進むなら
43              if self.tehai.shanten() <= cur_shanten:
44                  effect_count = 0
45
46                  # 残り全ての牌をツモってみる
47                  for hai in remain_hai:
48                      # 有効牌の数をカウント
49                      self.tehai.tsumo(hai)
50                      if self.tehai.shanten() < cur_shanten:
51                          effect_count += 1
52                      self.tehai.pop()
53
54                  # 有効牌が一番多い牌を選択
55                  if effect_count >= effect_max:
56                      effect_max = effect_count
57                      select_index = i
58
59              self.tehai.insert(i, pop_hai)
60
61          return select_index
62
63      # 立直するか
64      def on_richi(self):
65          return True
66
67      # ツモ和了するか
68      def on_tsumo(self):
69          return True
70
71      # ロン和了するか
72      def on_ron(self, target, whose):
73          return True
74
75      # 暗槓するか
76      def on_ankan(self, target):
77          # シャンテン数が下がらないなら暗槓
78          temp_tehai = copy.deepcopy(self.tehai)
79          temp_tehai.ankan(target)
80          return temp_tehai.shanten() <= self.tehai.shanten()
81
82      # 明槓するか
83      def on_minkan(self, hais, target, whose):
84          # 門前だったら明槓しない
85          if not self.furo:
86              return False
87
88          # シャンテン数が下がらないなら明槓
89          temp_tehai = copy.deepcopy(self.tehai)
```

```
90          temp_tehai.minkan(hais, target, 1)
91          return temp_tehai.shanten() <= self.tehai.shanten()
92
93      # 加槓するか
94      def on_kakan(self, target):
95          # シャンテン数が下がらないなら加槓
96          temp_tehai = copy.deepcopy(self.tehai)
97          temp_tehai.kakan(target)
98          return temp_tehai.shanten() <= self.tehai.shanten()
99
100     # ポンするか
101     def on_pon(self, hais, target, whose):
102         # シャンテン数が進むならポン
103         temp_tehai = copy.deepcopy(self.tehai)
104         temp_tehai.pon(hais, target, 1)
105         return temp_tehai.shanten() < self.tehai.shanten()
106
107     # チーするか
108     def on_chi(self, hais, target, whose):
109         # シャンテン数が進むならチー
110         temp_tehai = copy.deepcopy(self.tehai)
111         temp_tehai.chi(hais, target, 1)
112         return temp_tehai.shanten() < self.tehai.shanten()
113
114 # 面子手のみ
115 class AI(Tenari):
116     def __init__(self):
117         super().__init__()
118         self.name = "AI"
119
120     def on_minkan(self, hais, target, whose):
121         return False
122
123     def on_pon(self, hais, target, whose):
124         return False
125
126     def on_chi(self, hais, target, whose):
127         return False
```

リスト 12　mjgame/graphic/__init__.py

```
1 from .graphic import *
```

リスト 13　mjgame/graphic/graphic.py

```
1  import os
2  import sys
3  import time
4  import glob
5  from PIL import Image, ImageDraw, ImageFont, ImageTk
6  import numpy as np
7  import cv2
8  from .. import system as mj
9
10 # 麻雀牌のサイズ
11 MJHAI_WIDTH = 30
```

```
MJHAI_HEIGHT = 38
SCREEN_SIZE = 12 * MJHAI_HEIGHT + 7 * MJHAI_WIDTH

# フォントファイル
THIS_PATH = os.path.dirname(os.path.abspath(__file__))
FONT_FILE = THIS_PATH + "/font/YuGothB.ttc"

KAZE_NAME = ["東", "南", "西", "北"]

# 画像ファイル読み込み
hai_img = {}
mjhai_files = glob.glob(THIS_PATH + "/mjhai/*.png") # ファイル一覧を取得

for mjhai_file in mjhai_files:
    img_key, ext = os.path.splitext(os.path.basename(mjhai_file)) # ファイル名を抽出
    hai_img[img_key] = Image.open(mjhai_file)

t100_img = Image.open(THIS_PATH + "/image/100.png")
t1000_img = Image.open(THIS_PATH + "/image/1000.png")
remain_img = Image.open(THIS_PATH + "/image/remain.png")

# Pillow→OpenCV変換
def pil2cv(image):
    new_image = np.array(image)
    if new_image.shape[2] == 3: # カラー
        new_image = new_image[:, :, ::-1]
    elif new_image.shape[2] == 4: # 透過
        new_image = new_image[:, :, [2, 1, 0, 3]]
    return new_image

# 横向きの画像を生成
def draw_side(img):
    w, h = img.size
    create_img = Image.new("RGBA", (h, h))

    rotate_img = img.rotate(90, expand=True)
    create_img.paste(rotate_img, (0, h - w))

    return create_img

# 単色を合成した画像を生成
def draw_mix(img, color):
    create_img = Image.new("RGB", img.size)
    mix_img = Image.new("RGBA", img.size, color)

    create_img.paste(img)
    create_img.paste(mix_img, (0, 0), mix_img)
    return create_img

# 手牌の画像を生成
def draw_tehai(tehai, back=False):
    create_img = Image.new("RGBA", (14 * MJHAI_WIDTH + 4 * MJHAI_HEIGHT, 2 * MJHAI_HEIGHT))
    img_draw = ImageDraw.Draw(create_img)
    img_draw.font = ImageFont.truetype(FONT_FILE, 12)

    x = 0
```

```
    for i, hai in enumerate(tehai.hais):
        # 番号
        if not back:
            w, h = img_draw.textsize(str(i))
            img_draw.text(
                (x + (MJHAI_WIDTH - w) / 2, MJHAI_HEIGHT - h - 4),
                str(i)
            )

        # 麻雀牌
        mjhai_draw = hai_img["back" if back else hai.name]
        create_img.paste(mjhai_draw, (x, MJHAI_HEIGHT))
        x += MJHAI_WIDTH

    if tehai.tsumo_hai is not None:
        # ツモった牌は離す
        x += int(MJHAI_WIDTH / 4)

        # 番号
        if not back:
            w, h = img_draw.textsize(str(i + 1))
            img_draw.text(
                (x + (MJHAI_WIDTH - w) / 2, MJHAI_HEIGHT - h - 4),
                str(i + 1)
            )

        # 麻雀牌
        mjhai_draw = hai_img["back" if back else tehai.tsumo_hai.name]

        create_img.paste(mjhai_draw, (x, MJHAI_HEIGHT))
        x += MJHAI_HEIGHT

    # 副露
    x = create_img.size[0]
    for furo in tehai.furos:
        for i, hai in enumerate(furo.hais):
            # 麻雀牌
            if furo.kind == mj.FuroKind.ANKAN and (i == 0 or i == 3):
                mjhai_draw = hai_img["back"]
            else:
                mjhai_draw = hai_img[hai.name]

            if furo.kind == mj.FuroKind.KAKAN and i == 3:
                # 加槓
                create_img.paste(
                    draw_side(mjhai_draw),
                    (x + (3 - furo.direct) * MJHAI_WIDTH, MJHAI_HEIGHT - MJHAI_WIDTH)
                )
            else:
                # 他家からの牌は横にする
                if furo.kind != mj.FuroKind.ANKAN and furo.direct == i + 1:
                    create_img.paste(draw_side(mjhai_draw), (x - MJHAI_HEIGHT, MJHAI_HEIGHT
))
                    x -= MJHAI_HEIGHT
                else:
                    create_img.paste(mjhai_draw, (x - MJHAI_WIDTH, MJHAI_HEIGHT))
```

```
123                     x -= MJHAI_WIDTH
124
125     return create_img
126
127 # 河の画像を生成
128 def draw_kawa(kawa):
129     create_img = Image.new("RGBA", (5 * MJHAI_WIDTH + MJHAI_HEIGHT, 4 * MJHAI_HEIGHT))
130
131     x = 0
132     y = 0
133
134     for kawa_hai in kawa.hais:
135
136         paste_img = Image.new("RGB", (MJHAI_WIDTH, MJHAI_HEIGHT))
137         paste_img.paste(hai_img[kawa_hai.hai.name])
138
139         # ツモ切りは暗くする
140         if kawa_hai.tsumogiri:
141             paste_img = draw_mix(paste_img, (0, 0, 0, 47))
142
143         # 鳴かれた牌は青くする
144         if kawa_hai.furo:
145             paste_img = draw_mix(paste_img, (0, 63, 255, 47))
146
147         # 放銃した牌は赤くする
148         if kawa_hai.hoju:
149             paste_img = draw_mix(paste_img, (255, 63, 0, 47))
150
151         # 立直宣言牌は横にする
152         if kawa_hai.richi:
153             already_richi = True
154             create_img.paste(draw_side(paste_img), (x, y))
155             x += MJHAI_HEIGHT
156         else:
157             create_img.paste(paste_img, (x, y))
158             x += MJHAI_WIDTH
159
160         # 6枚で改行
161         if x >= 6 * MJHAI_WIDTH:
162             x = 0
163             y += MJHAI_HEIGHT
164
165     return create_img
166
167 # ゲーム情報
168 def draw_info(game):
169     size = 5 * MJHAI_WIDTH
170     create_img = Image.new("RGBA", (size, size))
171
172     # 局
173     kyoku_name = "{}{}局".format(KAZE_NAME[game.bakaze], game.kyoku + 1)
174
175     img_draw = ImageDraw.Draw(create_img)
176     img_draw.font = ImageFont.truetype(FONT_FILE, 20)
177     w, h = img_draw.textsize(kyoku_name)
178     img_draw.text(((size - w) / 2, 0), kyoku_name)
```

```
179
180     # 本場
181     img_draw.font = ImageFont.truetype(FONT_FILE, 16)
182     w, h = img_draw.textsize("× {}".format(game.honba))
183     img_draw.text(
184         (t100_img.size[0] + 2, MJHAI_WIDTH + (t100_img.size[1] - h) / 2),
185         "× {}".format(game.honba)
186     )
187
188     create_img.paste(t100_img, (2, MJHAI_WIDTH))
189
190     # 供託
191     w, h = img_draw.textsize("× {}".format(game.kyotaku))
192     img_draw.text(
193         (size - w - 2, MJHAI_WIDTH + (t1000_img.size[1] - h) / 2),
194         "× {}".format(game.kyotaku)
195     )
196
197     create_img.paste(t1000_img, (size - t1000_img.size[0] - w - 2, MJHAI_WIDTH))
198
199     # 残り
200     w, h = img_draw.textsize("× {:02}".format(game.yama_remain))
201     img_draw.text(
202         ((size + remain_img.size[0] - w) / 2, MJHAI_WIDTH + (remain_img.size[1] - h) / 2 +
    20),
203         "× {:02}".format(game.yama_remain)
204     )
205
206     create_img.paste(
207         remain_img,
208         (int((size - remain_img.size[0] - w) / 2), MJHAI_WIDTH + 20)
209     )
210
211     return create_img
212
213 # ドラ
214 def draw_dora(doras, uradoras):
215     create_img = Image.new("RGBA", (5 * MJHAI_WIDTH, 2 * MJHAI_HEIGHT))
216
217     for i in range(5):
218         # ドラ
219         if i < len(doras):
220             paste_img = hai_img[doras[i].name]
221         else:
222             paste_img = hai_img["back"]
223
224         create_img.paste(paste_img, (i * MJHAI_WIDTH, 0))
225
226         # 裏ドラ
227         if uradoras is not None and i < len(uradoras):
228             paste_img = hai_img[uradoras[i].name]
229         else:
230             paste_img = hai_img["back"]
231
232         create_img.paste(paste_img, (i * MJHAI_WIDTH, MJHAI_HEIGHT))
233
```

```
234     return create_img
235 
236 # ゲーム画面の画像を生成
237 def draw_screen(game, players, view):
238     create_img = Image.new("RGB", (SCREEN_SIZE, SCREEN_SIZE), "green")
239 
240     for i in range(game.player_num):
241         game_player = game.players[i]
242         player = None
243 
244         for cur_player in players:
245             if game_player.chicha == cur_player.chicha:
246                 player = cur_player
247 
248         paste_img = Image.new("RGBA", (SCREEN_SIZE, SCREEN_SIZE))
249 
250         # 手牌
251         if player is None:
252             if game_player.tehai.hais is None:
253                 tehai = mj.Tehai([mj.Hai(0, 0) for j in range(game_player.tehai.hai_num -
    1)], game_player.tehai.furos)
254                 tehai.tsumo(mj.Hai(0, 0))
255 
256                 if not game_player.tehai.exist_tsumo_hai:
257                     tehai.store()
258 
259                 tehai_img = draw_tehai(tehai, True)
260             else:
261                 tehai = mj.Tehai([hai for hai in game_player.tehai.hais], game_player.tehai
    .furos)
262                 tehai.tsumo(game_player.tehai.tsumo_hai)
263                 tehai_img = draw_tehai(tehai)
264         else:
265             tehai_img = draw_tehai(player.tehai)
266 
267         paste_img.paste(
268             tehai_img,
269             (SCREEN_SIZE - tehai_img.size[0], 7 * MJHAI_WIDTH + 10 * MJHAI_HEIGHT),
270             tehai_img
271         )
272 
273         # 河
274         kawa_img = draw_kawa(game_player.kawa)
275         paste_img.paste(
276             kawa_img,
277             (6 * MJHAI_HEIGHT + int(0.5 * MJHAI_WIDTH), 7 * MJHAI_WIDTH + 6 * MJHAI_HEIGHT)
    ,
278             kawa_img
279         )
280 
281         # 自風&点数
282         img_draw = ImageDraw.Draw(paste_img)
283         img_draw.font = ImageFont.truetype(FONT_FILE, 16)
284         jikaze = game_player.chicha - game.kyoku % game.player_num
285         w, h = img_draw.textsize("[{}] {}".format(KAZE_NAME[jikaze], game_player.point))
286 
```

```
287             img_draw.text(
288                 ((SCREEN_SIZE - w) / 2, 6.5 * MJHAI_WIDTH + 6 * MJHAI_HEIGHT - h / 2),
289                 "[{}] {}".format(KAZE_NAME[jikaze], game_player.point),
290                 (255, 255, 0)
291             )
292 
293             # 番
294             if game_player == game.cur_player:
295                 x = (SCREEN_SIZE - w) / 2 - 16
296                 y = 6.5 * MJHAI_WIDTH + 6 * MJHAI_HEIGHT - 5
297                 img_draw.rectangle((x, y, x + 10, y + 10), (255, 255, 127), (0, 0, 0))
298 
299             # プレイヤー名&シャンテン数
300             draw_str = game_player.name
301             if player is not None:
302                 draw_str += " [{}ST]".format(player.tehai.shanten())
303 
304             w, h = img_draw.textsize(draw_str)
305             img_draw.text(
306                 (SCREEN_SIZE - tehai_img.size[0], SCREEN_SIZE - tehai_img.size[1]),
307                 draw_str,
308             )
309 
310             # 回転&合成
311             rotate_img = paste_img.rotate((game_player.chicha - view.chicha) * 90)
312             create_img.paste(rotate_img, (0, 0), rotate_img)
313 
314         # ゲーム情報
315         info_img = draw_info(game)
316         create_img.paste(
317             info_img,
318             (6 * MJHAI_HEIGHT + MJHAI_WIDTH, 6 * MJHAI_HEIGHT + MJHAI_WIDTH),
319             info_img
320         )
321 
322         # ドラ
323         dora_img = draw_dora(game.dora_hais, game.uradora_hais)
324         create_img.paste(
325             dora_img,
326             (6 * MJHAI_HEIGHT + MJHAI_WIDTH, 4 * MJHAI_HEIGHT + 6 * MJHAI_WIDTH),
327             dora_img
328         )
329 
330         return create_img
331 
332 class Screen():
333     def __init__(self, game, players, view=None, title=""):
334         self.game = game
335         self.players = players
336         self.view = view
337         self.title = title
338 
339         # ウィンドウ名
340         self.win_name = self.title
341         if view is not None:
342             self.win_name += " [" + view.name + "]"
```

```
343
344     # 画面描画
345     def draw(self):
346         cur_view = self.game.cur_player if self.view is None else self.view
347         img = pil2cv(draw_screen(self.game, self.players, cur_view))
348         cv2.imshow(self.win_name, img)
349 
350         if cv2.waitKey(1) & 0xff == ord("q"):
351             sys.exit()
```