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Кафедра автоматизированных систем обработки информации и управления

ОТЧЕТ

по лабораторной работе № 6 по дисциплине
«Проектирование и анализ вычислительных алгоритмов»

„ Поиск в условиях противодействия ”

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СОДЕРЖАНИЕ

1 ЦЕЛЬ ЛАБОРАТОРНОЙ РАБОТЫ 3

2 ЗАДАНИЕ 4

3 ВЫПОЛНЕНИЕ...6

3.1 Псевдокод алгоритма..............**Error! Bookmark not defined.**

3.2 Анализ временной сложности **Error! Bookmark not defined.**

3.3 Программная реализация алгоритма..6

3.3.1 Исходный код 6

3.3.2 Примеры работы 22

3.4 Испытания алгоритма.............**Error! Bookmark not defined.**

3.4.1 Временные оценочные характеристики..... ***Error! Bookmark not defined.***

3.4.2 Графики зависимости временных оценочных характеристик и времени поиска от размерности структур ..... ***Error! Bookmark not defined.***

ВЫВОДЫ...24

КРИТЕРИИ ОЦЕНИВАНИЯ ..... ERROR! BOOKMARK NOT DEFINED.

1 ЦЕЛЬ ЛАБОРАТОРНОЙ РАБОТЫ

Цель работы – изучить основные подходы к формализации алгоритмов нахождения решений задач в условиях.

2 ЗАДАНИЕ

Согласно варианту (таблица 2.1) реализовать визуальное игровое приложение для игры пользователя с компьютерным оппонентом. Для реализации стратегии игры компьютерного оппонента использовать алгоритм альфа-бета-отсечений.

Реализовать три уровня сложности (легкий, средний, сложный) +1балл.

Сделать обобщенный вывод по лабораторной работе.

Таблица 2.1 – Варианты

№	**Вариант**
1	Баше https://ru.wikipedia.org/wiki/Баше_(игра)
2	Hexapawn https://ru.wikipedia.org/wiki/Hexapawn
3	Точки https://ru.wikipedia.org/wiki/Точки_(игра)
4	Dots and Boxes https://ru.wikipedia.org/wiki/Палочки_(игра)
5	Сим https://ru.wikipedia.org/wiki/Сим_(игра)
6	Snakes http://www.papg.com/show?3AE4
7	Cram https://en.wikipedia.org/wiki/Cram_(game)
8	Chomp http://www.papg.com/show?3AEA
9	Obstruction http://www.papg.com/show?2XMX
10	Gale http://www.papg.com/show?1TPI
11	Гомоку https://ru.wikipedia.org/wiki/Гомоку
12	Ним https://ru.wikipedia.org/wiki/Ним_(игра)
13	Col http://www.papg.com/show?2XLY
14	Hackenbush http://www.papg.com/show?1TMP
15	Snort http://www.papg.com/show?2XM1
16	Race Track http://www.papg.com/show?1TPE
17	3D Noughts and Crosses http://www.papg.com/show?1TND
18	Domineering http://www.papg.com/show?1TX6
19	Баше https://ru.wikipedia.org/wiki/Баше_(игра)

20	Hexapawn https://ru.wikipedia.org/wiki/Hexapawn
21	Точки https://ru.wikipedia.org/wiki/Точки_(игра)
22	Dots and Boxes https://ru.wikipedia.org/wiki/Палочки_(игра)
23	Сим https://ru.wikipedia.org/wiki/Сим_(игра)
24	Snakes http://www.papg.com/show?3AE4
25	Cram https://en.wikipedia.org/wiki/Cram_(game)
26	Chomp http://www.papg.com/show?3AEA
27	Obstruction http://www.papg.com/show?2XMX
28	Gale http://www.papg.com/show?1TPI
29	Гомоку https://ru.wikipedia.org/wiki/Гомоку
30	Ним https://ru.wikipedia.org/wiki/Ним_(игра)

3 ВЫПОЛНЕНИЕ

3.1 Программная реализация

3.1.1 Исходный код

```
##############
## NIM game ##
##############
# from tkinter import Tk, Canvas, Frame, Button, LEFT, RIGHT, messagebox, CURRENT, Label,
Entry, Checkbutton
from tkinter import *
from random import randint

def on_click(event): #this deals with actions from clicks based on the name of the button
clicked on
    if canvas.find_withtag(CURRENT):
        global last_piece, piece_name

        piece_name = canvas.gettags(CURRENT)[0]
        group_name = piece_name[0]
        if pieces == [7,5,3]:
            last_piece = None

        try:
            if piece_name == "AI_first":
                AI_to_play()
            elif group_name != last_piece and last_piece != None and piece_name != 'DONE':
                # display ILLEGAL MOVE in the game canvas for 1.5 seconds if the user tries to
pick pieces from different piles on the same turn
                canvas.create_text(355,    40,    text="ILLEGAL    MOVE",    font="Purisa",
tags="ILLEGAL_WARNING", fill="black",command=None)
                canvas.update_idletasks()
                canvas.after(1500)
                canvas.delete("ILLEGAL_WARNING")
            else:
                if piece_name == 'DONE' and last_piece != 'DONE' and last_piece != None:
                    last_piece = None
                    AI_to_play() # this is for the computer's turn when the user has clicked
the Done button
                elif piece_name == 'DONE' and last_piece == None:
                    # do not let the user click the done button more than once in a row.
Displays the message for 1.5 seconds
                    canvas.create_text(355,  40,  text="YOU  HAVE  NOT  MADE  ANY  MOVES",
font="Purisa", tags="DOUBLE_DONE",fill="black", command=None)
                    canvas.update_idletasks()
                    canvas.after(1500)
                    canvas.delete("DOUBLE_DONE")
                elif piece_name == 'WON_BUTTON':
                    pass
                else:
                    canvas.delete('AI_first')
```

```
                        update_board(piece_name)
                        canvas.delete(piece_name)
                        last_piece = piece_name[0]
                        if sum(pieces) == 0:
                            game_over('computer')
                except NameError:
                    last_piece = group_name
                    if piece_name == 'DONE':
                        AI_to_play()  # this is the computer's turn when the user has clicked the Done
button
                    elif piece_name == 'WON_BUTTON':
                        pass
                    else:
                        update_board(piece_name)
                        canvas.delete(piece_name)
                        # this should only happen on first go and is to catch the case where the last
button press is not defined
                        last_piece = piece_name[0]
                        if sum(pieces) == 0:
                            game_over('computer')

        def create_pieces():

            # ititialise the mathematical representations of the board and declare as global variable
so it can easily be updated within the update function
            global pieces, board, piece_name
            pieces = [7, 5, 3]
            board = [[1,1,1,1,1,1,1],[1,1,1,1,1],[1,1,1]]
            piece_name = 'NEW_GAME'

            circle_size = 50
            linecolour = "black"
            fillcolour = "blue"

            # Group A is on the left. It is a group of 7
            A1x = 50
            A1y = 50
            A2x = 110
            A2y = 50
            A3x = 20
            A3y = 105
            A4x = 80
            A4y = 105
            A5x = 140
            A5y = 105
            A6x = 50
            A6y = 160
            A7x = 110
            A7y = 160
            canvas.create_oval(A1x,          A1y,          A1x+circle_size,          A1y+circle_size,
outline=linecolour,fill=fillcolour,tags="A1")
            canvas.create_oval(A2x,          A2y,          A2x+circle_size,          A2y+circle_size,
outline=linecolour,fill=fillcolour,tags="A2")
```

```
            canvas.create_oval(A3x,          A3y,          A3x+circle_size,          A3y+circle_size,
outline=linecolour,fill=fillcolour,tags="A3")
            canvas.create_oval(A4x,          A4y,          A4x+circle_size,          A4y+circle_size,
outline=linecolour,fill=fillcolour,tags="A4")
            canvas.create_oval(A5x,          A5y,          A5x+circle_size,          A5y+circle_size,
outline=linecolour,fill=fillcolour,tags="A5")
            canvas.create_oval(A6x,          A6y,          A6x+circle_size,          A6y+circle_size,
outline=linecolour,fill=fillcolour,tags="A6")
            canvas.create_oval(A7x,          A7y,          A7x+circle_size,          A7y+circle_size,
outline=linecolour,fill=fillcolour,tags="A7")

            # Group B is in the centre. It is a group of 5
            B1x = 330
            B1y = 65
            B2x = 280
            B2y = 105
            B3x = 380
            B3y = 105
            B4x = 300
            B4y = 160
            B5x = 360
            B5y = 160
            canvas.create_oval(B1x,          B1y,          B1x+circle_size,          B1y+circle_size,
outline=linecolour,fill=fillcolour,tags="B1")
            canvas.create_oval(B2x,          B2y,          B2x+circle_size,          B2y+circle_size,
outline=linecolour,fill=fillcolour,tags="B2")
            canvas.create_oval(B3x,          B3y,          B3x+circle_size,          B3y+circle_size,
outline=linecolour,fill=fillcolour,tags="B3")
            canvas.create_oval(B4x,          B4y,          B4x+circle_size,          B4y+circle_size,
outline=linecolour,fill=fillcolour,tags="B4")
            canvas.create_oval(B5x,          B5y,          B5x+circle_size,          B5y+circle_size,
outline=linecolour,fill=fillcolour,tags="B5")

            # Group C is on the right. It is a group of 3
            C1x = 570
            C1y = 105
            C2x = 540
            C2y = 160
            C3x = 600
            C3y = 160
            canvas.create_oval(C1x,          C1y,          C1x+circle_size,          C1y+circle_size,
outline=linecolour,fill=fillcolour,tags="C1")
            canvas.create_oval(C2x,          C2y,          C2x+circle_size,          C2y+circle_size,
outline=linecolour,fill=fillcolour,tags="C2")
            canvas.create_oval(C3x,          C3y,          C3x+circle_size,          C3y+circle_size,
outline=linecolour,fill=fillcolour,tags="C3")

        def create_DONE_button():
            canvas.create_rectangle(580,2,680,45,outline="black",fill="gray80",tags="DONE")
            canvas.create_text(630,23,text="I'm done with\n     my turn",font="Purisa",tags="DONE")

        def create_computer_go_first_button():
            canvas.create_rectangle(580,48,680,91,outline="black",fill="gray80",tags="AI_first")
            canvas.create_text(630,70,text="The          computer\n                    can          go
first",font="Purisa",tags="AI_first")

        def create_operation_buttons():
            # create the buttons to start the game and show the rules
            operation_frame = Frame()
            operation_frame.pack(fill="both", expand=True)
            Start  =  Button(operation_frame,  text='Click  here  to  start  a  new  game',  height=2,
command=start_game, bg='white',fg='navy')
            Start.pack(fill="both", expand=True, side=LEFT)
            Rules = Button(operation_frame, text='Click here to see the rules', command=show_rules,
height=2, bg='navy',fg='white')
            Rules.pack(fill="both", expand=True, side=RIGHT)

        def start_game():
            # this turns all the ovals into buttons to be activated by a mouse click. Function then
jumps to on_click.
            # lvl = Toplevel()
            # Label(lvl,  text='Message!').pack()
            global box
            box = Frame()
            w = Button(box, text="Low lvl", width=10, command=low_lvl)
            w.pack(side=LEFT, padx=5, pady=5)
            w = Button(box, text="Middle lvl", width=10, command=middle_lvl, default=ACTIVE)
            w.pack(side=LEFT, padx=5, pady=5)
            w = Button(box, text="High lvl", width=10, command=high_lvl)
            w.pack(side=LEFT, padx=5, pady=5)

            # bind("&lt;Return>", self.ok)
            # bind("&lt;Escape>", self.cancel)

            box.pack()



            create_pieces()
            create_DONE_button()
            create_computer_go_first_button()
            canvas.delete('WON_BUTTON')
            canvas.bind("<Button-1>",func=on_click)

        def low_lvl():
            global box, lvl
            lvl = 1
            box.forget()

        def middle_lvl():
            global box, lvl
            lvl = 2
            box.forget()

        def high_lvl():
            global box, lvl
            lvl = 3
            box.forget()
        def show_rules():
            rules_intro = 'Welcome to Nim, a game with more strategy than may first appear!\n'
            game_play = 'Playing Nim involves each player taking pieces from the game screen in
turns.\n'
            rule1 = 'Your goal is to leave your opponent with the last piece remaining on the screen.\n'
            rule2 = 'You may only take from one pile each turn.\n'
            rule3 = 'You can take as many pieces as you want each turn.\n\n'
            operation = 'When you are done with your turn, please click the button in the top right
corner to let the computer know that it can play.'
            rule_message = rules_intro+game_play+rule1+rule2+rule3+operation
            messagebox.showinfo("How to play Nim", rule_message)

        def update_board(piece_names):
            # the board had two representations, the "pieces" representation is [7,5,3].
            # the "board" representation has all the pieces and looks like
[[1,1,1,1,1,1,1],[1,1,1,1,1],[1,1,1]].
            if type(piece_names) == str:    #need to tell if there is a single or multiple updates to
be done
                update_board_pieces(piece_names)
            else:
                for item in range(0, len(piece_names)): # multiple updates are required when the AI
makes its moves
                    piece_name = piece_names[item]
                    update_board_pieces(piece_name)

        def update_board_pieces(piece_name):
            # this part adjusts the mathematical representations of the board, being the [7,5,3] and
[[1,1,1,1,1,1,1],[1,1,1,1,1],[1,1,1]] arrays.
            # these arrays are global variables defined when the board is created
            group_name = piece_name[0]
            if group_name == 'A':
                pieces[0] -= 1
            elif group_name == 'B':
                pieces[1] -= 1
            elif group_name == 'C':
                pieces[2] -= 1

            if piece_name == 'A1':
                board[0][0] = 0
            elif piece_name == 'A2':
                board[0][1] = 0
            elif piece_name == 'A3':
                board[0][2] = 0
            elif piece_name == 'A4':
                board[0][3] = 0
            elif piece_name == 'A5':
                board[0][4] = 0
            elif piece_name == 'A6':
                board[0][5] = 0
            elif piece_name == 'A7':
                board[0][6] = 0
            elif piece_name == 'B1':
                board[1][0] = 0
            elif piece_name == 'B2':
                board[1][1] = 0
            elif piece_name == 'B3':
                board[1][2] = 0
            elif piece_name == 'B4':
                board[1][3] = 0
            elif piece_name == 'B5':
                board[1][4] = 0
            elif piece_name == 'C1':
                board[2][0] = 0
            elif piece_name == 'C2':
                board[2][1] = 0
            elif piece_name == 'C3':
                board[2][2] = 0

        def AI_to_play():
            # this finds the computer's action using the strategies defined
            next_move = find_next_move()
            print(next_move)
            canvas.delete("AI_first")

            # this applies the strategy and consist of the computer building a list of board moves it
    must make to apply the strategy has determined is best
            if finish == False:
                # delta is the difference is the current state and the future state of the board
                # delta should only every have 1 number of the 3 that is greater than zero. eg. [0,3,0]
    tells the program to remove 3 pieced from pile B
                delta = [pieces[0] - next_move[0], pieces[1] - next_move[1], pieces[2] - next_move[2]]
                pieces_to_take = []

                if delta[0] > 0:
                    # take from A
                    piece_index = 0
                    number_of_pieces_to_take = delta[0]
                    while number_of_pieces_to_take > 0:
                        if board[0][piece_index] == 1:
                            board[0][piece_index] = 0
                            pieces[0] -= 1
                            piece_index += 1
                            number_of_pieces_to_take -= 1
                            pieces_to_take.append('A' + str(piece_index))
                        else:
                            piece_index += 1
                elif delta[1] > 0:
                    # take from B
                    piece_index = 0
                    number_of_pieces_to_take = delta[1]
                    while number_of_pieces_to_take > 0:
                        if board[1][piece_index] == 1:
                            board[1][piece_index] = 0
                            pieces[1] -= 1
                            piece_index += 1
                            number_of_pieces_to_take -= 1
                            pieces_to_take.append('B' + str(piece_index))
                    else:
                        piece_index += 1
                elif delta[2] > 0:
                    # take from C
                    piece_index = 0
                    number_of_pieces_to_take = delta[2]
                    while number_of_pieces_to_take > 0:
                        if board[2][piece_index] == 1:
                            board[2][piece_index] = 0
                            pieces[2] -= 1
                            piece_index += 1
                            number_of_pieces_to_take -= 1
                            pieces_to_take.append('C' + str(piece_index))
                        else:
                            piece_index += 1

            # this is the computer actually making the moves iteratively for each move it has decided
            if finish == False:
                for piece in pieces_to_take:
                    canvas.itemconfig(piece, fill="yellow") # change the colour of the pieces the AI
selects to yellow before deleting them
                    canvas.update_idletasks()
                    canvas.after(500) #500ms delay to allow the user to see the pieces change colour
before the AI deletes them
                    canvas.delete(piece) # delete each piece the AI selects
                    if sum(pieces) == 0: #check if the user has won
                        game_over('user')

        def game_over(who_won):  # displays the final message of who won

            button_width = 190
            button_height = 40
            BX = 260
            BY = 110
            canvas.delete('DONE')
            canvas.create_rectangle(BX, BY, BX + button_width, BY + button_height, outline="black",
fill="grey80",
                                    tags="WON_BUTTON", command=None)
            if who_won == 'user':
                canvas.create_text(BX + 95, BY + 20, text="!!! YOU WON !!!", font="Purisa",
tags="WON_BUTTON",
                                   fill="black", command=None)
            elif who_won == 'computer':
                canvas.create_text(BX + 95, BY + 20, text="THE COMPUTER WON", font="Purisa",
tags="WON_BUTTON",
                                   fill="red", command=None)

        # this is a very prescriptive strategy where each move has been typed explicitly.
        # anywhere there is a choice (randint) is where the computer does not have a clear strategy
and may try and trick the user into making a mistake
        def find_next_move():
            global finish, lvl

            if lvl == 1:
                if randint(0, 1) == 0:
                    next_move = [1, 0, 0]
            if lvl == 2:
                if randint(0, 2) == 0:
                    next_move = [1, 0, 0]

            finish = False
            next_move = []
            choice = randint(1,3)
            choice1 = randint(1,2)
            if pieces == [7, 5, 3]: #this is the opening move if you ask the AI to play first. It will
pick one of two options
                if choice1 < 2:
                    next_move = [7, 4, 3]
                else:
                    next_move = [7, 5, 2]
            elif pieces == [7, 5, 2]: #every other choice is a matter of 3 options
                if choice == 1:
                    next_move = [6, 5, 2]
                elif choice == 2:
                    next_move = [4, 5, 2]
                else:
                    next_move = [7, 4, 2]
            elif pieces == [7, 5, 1]: # if there is a clear best move then the computer will always
play that
                next_move = [4, 5, 1]
            elif pieces == [7, 5, 0]:
                next_move = [5, 5, 0]
            elif pieces == [7, 4, 3]:
                if choice == 1:
                    next_move = [6, 4, 3]
                elif choice == 2:
                    next_move = [7, 4, 2]
                else:
                    next_move = [7, 4, 1]
            elif pieces == [7, 4, 2]:
                next_move = [6, 4, 2]
            elif pieces == [7, 4, 1]:
                next_move = [5, 4, 1]
            elif pieces == [7, 4, 0]:
                next_move = [4, 4, 0]
            elif pieces == [7, 3, 3]:
                next_move = [0, 3, 3]
            elif pieces == [7, 3, 2]:
                next_move = [1, 3, 2]
            elif pieces == [7, 3, 1]:
                next_move = [2, 3, 1]
            elif pieces == [7, 3, 0]:
                next_move = [3, 3, 0]
            elif pieces == [7, 2, 3]:
                next_move = [1, 2, 3]
            elif pieces == [7, 2, 2]:
                next_move = [2, 2, 2]
            elif pieces == [7, 2, 1]:
```

```
        next_move = [3, 2, 1]
    elif pieces == [7, 2, 0]:
        next_move = [2, 2, 0]
    elif pieces == [7, 1, 3]:
        next_move = [2, 1, 3]
    elif pieces == [7, 1, 2]:
        next_move = [3, 1, 2]
    elif pieces == [7, 1, 1]:
        next_move = [1, 1, 1]
    elif pieces == [7, 1, 0]:
        next_move = [0, 1, 0]
    elif pieces == [7, 0, 3]:
        next_move = [3, 0, 3]
    elif pieces == [7, 0, 2]:
        next_move = [2, 0, 2]
    elif pieces == [7, 0, 1]:
        next_move = [0, 0, 1]
    elif pieces == [7, 0, 0]:
        next_move = [1, 0, 0]
    elif pieces == [6, 5, 3]:
        if choice == 1:
            next_move = [6, 4, 3]
        elif choice == 2:
            next_move = [6, 5, 2]
        else:
            next_move = [4, 5, 3]
    elif pieces == [6, 5, 2]:
        next_move = [6, 4, 2]
    elif pieces == [6, 5, 1]:
        next_move = [4, 5, 1]
    elif pieces == [6, 5, 0]:
        next_move = [5, 5, 0]
    elif pieces == [6, 4, 3]:
        next_move = [6, 4, 2]
    elif pieces == [6, 4, 2]:
        if choice == 1:
            next_move = [6, 4, 1]
        elif choice == 2:
            next_move = [5, 4, 2]
        else:
            next_move = [3, 4, 2]
    elif pieces == [6, 4, 1]:
        next_move = [5, 4, 1]
    elif pieces == [6, 4, 0]:
        next_move = [4, 4, 0]
    elif pieces == [6, 3, 3]:
        next_move = [0, 3, 3]
    elif pieces == [6, 3, 2]:
        next_move = [1, 3, 2]
    elif pieces == [6, 3, 1]:
        next_move = [2, 3, 1]
    elif pieces == [6, 3, 0]:
        next_move = [3, 3, 0]
    elif pieces == [6, 2, 3]:
```

```
    next_move = [1, 2, 3]
elif pieces == [6, 2, 2]:
    next_move = [0, 2, 2]
elif pieces == [6, 2, 1]:
    next_move = [3, 2, 1]
elif pieces == [6, 2, 0]:
    next_move = [2, 2, 0]
elif pieces == [6, 1, 3]:
    next_move = [2, 1, 3]
elif pieces == [6, 1, 2]:
    next_move = [3, 1, 2]
elif pieces == [6, 1, 1]:
    next_move = [1, 1, 1]
elif pieces == [6, 1, 0]:
    next_move = [0, 1, 0]
elif pieces == [6, 0, 3]:
    next_move = [3, 0, 3]
elif pieces == [6, 0, 2]:
    next_move = [2, 0, 2]
elif pieces == [6, 0, 1]:
    next_move = [0, 0, 1]
elif pieces == [6, 0, 0]:
    next_move = [1, 0, 0]
elif pieces == [5, 5, 3]:
    next_move = [5, 5, 0]
elif pieces == [5, 5, 2]:
    next_move = [5, 5, 0]
elif pieces == [5, 5, 1]:
    next_move = [5, 5, 0]
elif pieces == [5, 5, 0]:
    if choice == 1:
        next_move = [5, 2, 0]
    elif choice == 2:
        next_move = [3, 5, 0]
    else:
        next_move = [2, 5, 0]
elif pieces == [5, 4, 3]:
    next_move = [5, 4, 1]
elif pieces == [5, 4, 2]:
    next_move = [5, 4, 1]
elif pieces == [5, 4, 1]:
    if choice == 1:
        next_move = [5, 3, 1]
    elif choice == 2:
        next_move = [3, 4, 1]
    else:
        next_move = [4, 4, 1]
elif pieces == [5, 4, 0]:
    next_move = [4, 4, 0]
elif pieces == [5, 3, 3]:
    next_move = [0, 3, 3]
elif pieces == [5, 3, 2]:
    next_move = [1, 3, 2]
elif pieces == [5, 3, 1]:
    next_move = [2, 3, 1]
elif pieces == [5, 3, 0]:
    next_move = [3, 3, 0]
elif pieces == [5, 2, 3]:
    next_move = [1, 2, 3]
elif pieces == [5, 2, 2]:
    next_move = [0, 2, 2]
elif pieces == [5, 2, 1]:
    next_move = [3, 2, 1]
elif pieces == [5, 2, 0]:
    next_move = [2, 2, 0]
elif pieces == [5, 1, 3]:
    next_move = [2, 1, 3]
elif pieces == [5, 1, 2]:
    next_move = [3, 1, 2]
elif pieces == [5, 1, 1]:
    next_move = [1, 1, 1]
elif pieces == [5, 1, 0]:
    next_move = [0, 1, 0]
elif pieces == [5, 0, 3]:
    next_move = [3, 0, 3]
elif pieces == [5, 0, 2]:
    next_move = [2, 0, 2]
elif pieces == [5, 0, 1]:
    next_move = [0, 0, 1]
elif pieces == [5, 0, 0]:
    next_move = [1, 0, 0]
elif pieces == [4, 5, 3]:
    next_move = [4, 5, 1]
elif pieces == [4, 5, 2]:
    next_move = [4, 5, 1]
elif pieces == [4, 5, 1]:
    if choice == 1:
        next_move = [3, 5, 1]
    elif choice == 2:
        next_move = [2, 5, 1]
    else:
        next_move = [4, 3, 1]
elif pieces == [4, 5, 0]:
    next_move = [4, 4, 0]
elif pieces == [4, 4, 3]:
    next_move = [4, 4, 0]
elif pieces == [4, 4, 2]:
    next_move = [4, 4, 0]
elif pieces == [4, 4, 1]:
    next_move = [4, 4, 0]
elif pieces == [4, 4, 0]:
    if choice == 1:
        next_move = [4, 2, 0]
    elif choice == 2:
        next_move = [3, 4, 0]
    else:
        next_move = [4, 1, 0]
elif pieces == [4, 3, 3]:
```

```
    next_move = [0, 3, 3]
elif pieces == [4, 3, 2]:
    next_move = [1, 3, 2]
elif pieces == [4, 3, 1]:
    next_move = [2, 3, 1]
elif pieces == [4, 3, 0]:
    next_move = [3, 3, 0]
elif pieces == [4, 2, 3]:
    next_move = [1, 2, 3]
elif pieces == [4, 2, 2]:
    next_move = [0, 2, 2]
elif pieces == [4, 2, 1]:
    next_move = [3, 2, 1]
elif pieces == [4, 2, 0]:
    next_move = [2, 2, 0]
elif pieces == [4, 1, 3]:
    next_move = [2, 1, 3]
elif pieces == [4, 1, 2]:
    next_move = [3, 1, 2]
elif pieces == [4, 1, 1]:
    next_move = [1, 1, 1]
elif pieces == [4, 1, 0]:
    next_move = [0, 1, 0]
elif pieces == [4, 0, 3]:
    next_move = [3, 0, 3]
elif pieces == [4, 0, 2]:
    next_move = [2, 0, 2]
elif pieces == [4, 0, 1]:
    next_move = [0, 0, 1]
elif pieces == [4, 0, 0]:
    next_move = [1, 0, 0]
elif pieces == [3, 5, 3]:
    next_move = [3, 0, 3]
elif pieces == [3, 5, 2]:
    next_move = [3, 1, 2]
elif pieces == [3, 5, 1]:
    next_move = [3, 2, 1]
elif pieces == [3, 5, 0]:
    next_move = [3, 3, 0]
elif pieces == [3, 4, 3]:
    next_move = [3, 0, 3]
elif pieces == [3, 4, 2]:
    next_move = [3, 1, 2]
elif pieces == [3, 4, 1]:
    next_move = [3, 2, 1]
elif pieces == [3, 4, 0]:
    next_move = [3, 3, 0]
elif pieces == [3, 3, 3]:
    next_move = [3, 0, 3]
elif pieces == [3, 3, 2]:
    next_move = [3, 3, 0]
elif pieces == [3, 3, 1]:
    next_move = [3, 3, 0]
elif pieces == [3, 3, 0]:
    if choice == 1:
        next_move = [3, 2, 0]
    elif choice == 2:
        next_move = [1, 3, 0]
    else:
        next_move = [3, 1, 0]
elif pieces == [3, 2, 3]:
    next_move = [3, 0, 3]
elif pieces == [3, 2, 2]:
    next_move = [0, 2, 2]
elif pieces == [3, 2, 1]:
    if choice == 1:
        next_move = [1, 2, 1]
    elif choice == 2:
        next_move = [3, 0, 1]
    else:
        next_move = [2, 2, 1]
elif pieces == [3, 2, 0]:
    next_move = [2, 2, 0]
elif pieces == [3, 1, 3]:
    next_move = [3, 0, 3]
elif pieces == [3, 1, 2]:
    if choice == 1:
        next_move = [1, 1, 2]
    elif choice == 2:
        next_move = [3, 0, 2]
    else:
        next_move = [2, 1, 2]
elif pieces == [3, 1, 1]:
    next_move = [1, 1, 1]
elif pieces == [3, 1, 0]:
    next_move = [0, 1, 0]
elif pieces == [3, 0, 3]:
    if choice == 1:
        next_move = [2, 0, 3]
    elif choice == 2:
        next_move = [3, 0, 2]
    else:
        next_move = [1, 0, 3]
elif pieces == [3, 0, 2]:
    next_move = [2, 0, 2]
elif pieces == [3, 0, 1]:
    next_move = [0, 0, 1]
elif pieces == [3, 0, 0]:
    next_move = [1, 0, 0]
elif pieces == [2, 5, 3]:
    next_move = [2, 1, 3]
elif pieces == [2, 5, 2]:
    next_move = [2, 0, 2]
elif pieces == [2, 5, 1]:
    next_move = [2, 3, 1]
elif pieces == [2, 5, 0]:
    next_move = [2, 2, 0]
elif pieces == [2, 4, 3]:
    next_move = [2, 1, 3]
elif pieces == [2, 4, 2]:
    next_move = [2, 0, 2]
elif pieces == [2, 4, 1]:
    next_move = [2, 3, 1]
elif pieces == [2, 4, 0]:
    next_move = [2, 2, 0]
elif pieces == [2, 3, 3]:
    next_move = [0, 3, 3]
elif pieces == [2, 3, 2]:
    next_move = [2, 0, 2]
elif pieces == [2, 3, 1]:
    if choice == 1:
        next_move = [2, 2, 1]
    elif choice == 2:
        next_move = [0, 3, 1]
    else:
        next_move = [2, 1, 1]
elif pieces == [2, 3, 0]:
    next_move = [2, 2, 0]
elif pieces == [2, 2, 3]:
    next_move = [2, 2, 0]
elif pieces == [2, 2, 2]:
    next_move = [2, 0, 2]
elif pieces == [2, 2, 1]:
    next_move = [2, 2, 0]
elif pieces == [2, 2, 0]:
    if choice == 1:
        next_move = [2, 0, 0]
    elif choice == 2:
        next_move = [1, 2, 0]
    else:
        next_move = [2, 1, 0]
elif pieces == [2, 1, 3]:
    if choice == 1:
        next_move = [2, 1, 2]
    elif choice == 2:
        next_move = [2, 1, 1]
    else:
        next_move = [1, 1, 3]
elif pieces == [2, 1, 2]:
    next_move = [2, 0, 2]
elif pieces == [2, 1, 1]:
    next_move = [1, 1, 1]
elif pieces == [2, 1, 0]:
    next_move = [0, 1, 0]
elif pieces == [2, 0, 3]:
    next_move = [2, 0, 2]
elif pieces == [2, 0, 2]:
    if choice == 1:
        next_move = [2, 0, 1]
    elif choice == 2:
        next_move = [1, 0, 2]
    else:
        next_move = [2, 0, 0]
elif pieces == [2, 0, 1]:
    next_move = [0, 0, 1]
elif pieces == [2, 0, 0]:
    next_move = [1, 0, 0]
elif pieces == [1, 5, 3]:
    next_move = [1, 2, 3]
elif pieces == [1, 5, 2]:
    next_move = [1, 3, 2]
elif pieces == [1, 5, 1]:
    next_move = [1, 1, 1]
elif pieces == [1, 5, 0]:
    next_move = [1, 0, 0]
elif pieces == [1, 4, 3]:
    next_move = [1, 2, 3]
elif pieces == [1, 4, 2]:
    next_move = [1, 3, 2]
elif pieces == [1, 4, 1]:
    next_move = [1, 1, 1]
elif pieces == [1, 4, 0]:
    next_move = [1, 0, 0]
elif pieces == [1, 3, 3]:
    next_move = [0, 3, 3]
elif pieces == [1, 3, 2]:
    if choice == 1:
        next_move = [1, 2, 2]
    elif choice == 2:
        next_move = [1, 3, 1]
    else:
        next_move = [1, 1, 2]
elif pieces == [1, 3, 1]:
    next_move = [1, 1, 1]
elif pieces == [1, 3, 0]:
    next_move = [1, 0, 0]
elif pieces == [1, 2, 3]:
    if choice == 1:
        next_move = [1, 2, 2]
    elif choice == 2:
        next_move = [1, 2, 1]
    else:
        next_move = [1, 1, 3]
elif pieces == [1, 2, 2]:
    next_move = [0, 2, 2]
elif pieces == [1, 2, 1]:
    next_move = [1, 1, 1]
elif pieces == [1, 2, 0]:
    next_move = [1, 0, 0]
elif pieces == [1, 1, 3]:
    next_move = [1, 1, 1]
elif pieces == [1, 1, 2]:
    next_move = [1, 1, 1]
elif pieces == [1, 1, 1]:
    if choice == 1:
        next_move = [1, 0, 1]
    elif choice == 2:
        next_move = [1, 1, 0]
    else:
        next_move = [0, 1, 1]
elif pieces == [1, 1, 0]:
    next_move = [1, 0, 0]
elif pieces == [1, 0, 3]:
    next_move = [1, 0, 0]
elif pieces == [1, 0, 2]:
    next_move = [1, 0, 0]
elif pieces == [1, 0, 1]:
    next_move = [1, 0, 0]
elif pieces == [1, 0, 0]:
    next_move = [0, 0, 0]
elif pieces == [0, 5, 3]:
    next_move = [0, 3, 3]
elif pieces == [0, 5, 2]:
    next_move = [0, 2, 2]
elif pieces == [0, 5, 1]:
    next_move = [0, 0, 1]
elif pieces == [0, 5, 0]:
    next_move = [0, 1, 0]
elif pieces == [0, 4, 3]:
    next_move = [0, 3, 3]
elif pieces == [0, 4, 2]:
    next_move = [0, 2, 2]
elif pieces == [0, 4, 1]:
    next_move = [0, 0, 1]
elif pieces == [0, 4, 0]:
    next_move = [0, 1, 0]
elif pieces == [0, 3, 3]:
    if choice == 1:
        next_move = [0, 3, 2]
    elif choice == 2:
        next_move = [0, 2, 3]
    else:
        next_move = [0, 3, 1]
elif pieces == [0, 3, 2]:
    next_move = [0, 2, 2]
elif pieces == [0, 3, 1]:
    next_move = [0, 0, 1]
elif pieces == [0, 3, 0]:
    next_move = [0, 1, 0]
elif pieces == [0, 2, 3]:
    next_move = [0, 2, 1]
elif pieces == [0, 2, 2]:
    if choice == 1:
        next_move = [0, 1, 2]
    elif choice == 2:
        next_move = [0, 2, 1]
    else:
        next_move = [0, 2, 0]
elif pieces == [0, 2, 1]:
    next_move = [0, 0, 1]
    elif pieces == [0, 2, 0]:
        next_move = [0, 1, 0]
    elif pieces == [0, 1, 3]:
        next_move = [0, 1, 0]
    elif pieces == [0, 1, 2]:
        next_move = [0, 1, 0]
    elif pieces == [0, 1, 1]:
        next_move = [0, 1, 0]
    elif pieces == [0, 1, 0]:
        next_move = [0, 0, 0]
    elif pieces == [0, 0, 3]:
        next_move = [0, 0, 1]
    elif pieces == [0, 0, 2]:
        next_move = [0, 0, 1]
    elif pieces == [0, 0, 1]:
        next_move = [0, 0, 0]
    elif pieces == [0, 0, 0]:
        finish = True
    return next_move

#this is the main program
root = Tk()
root.title('Nim')
canvas = Canvas(root, width=680, height=250)
canvas.pack()
create_pieces()
create_operation_buttons()
root.mainloop()
```

3.1.2 Примеры работы

На рисунках 3.1 и 3.2 показаны примеры работы программы.

Рисунок 3.1

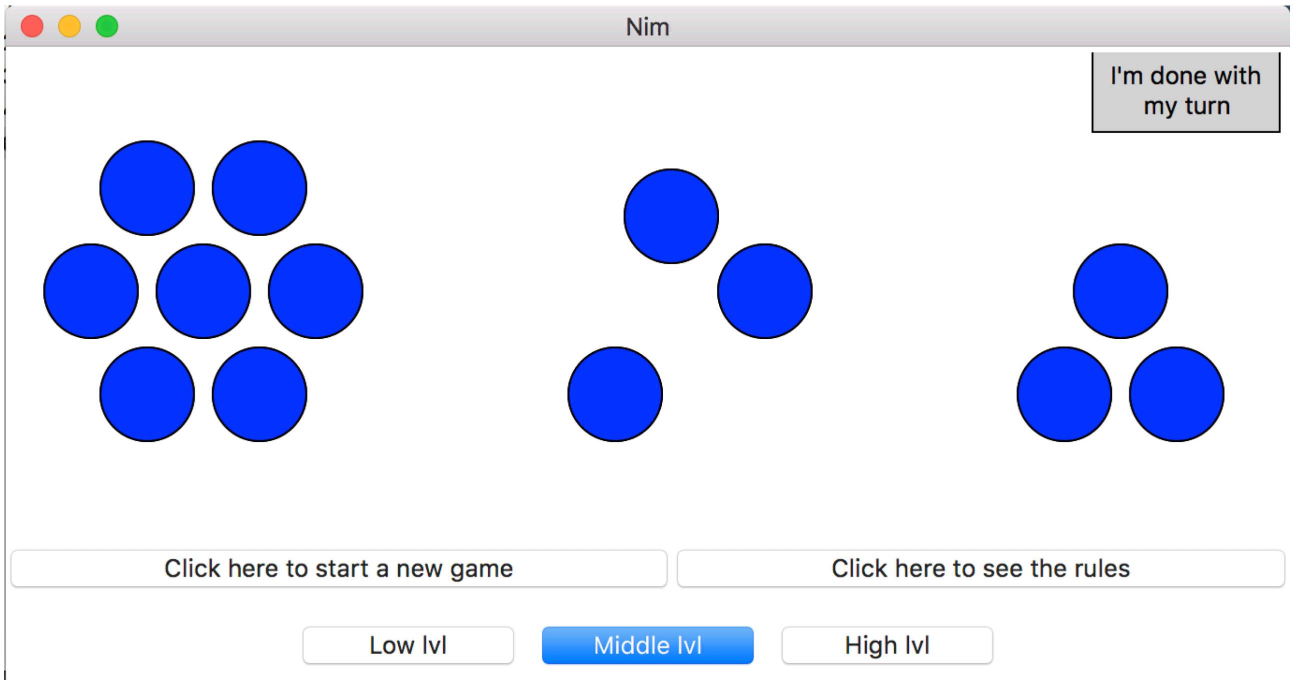
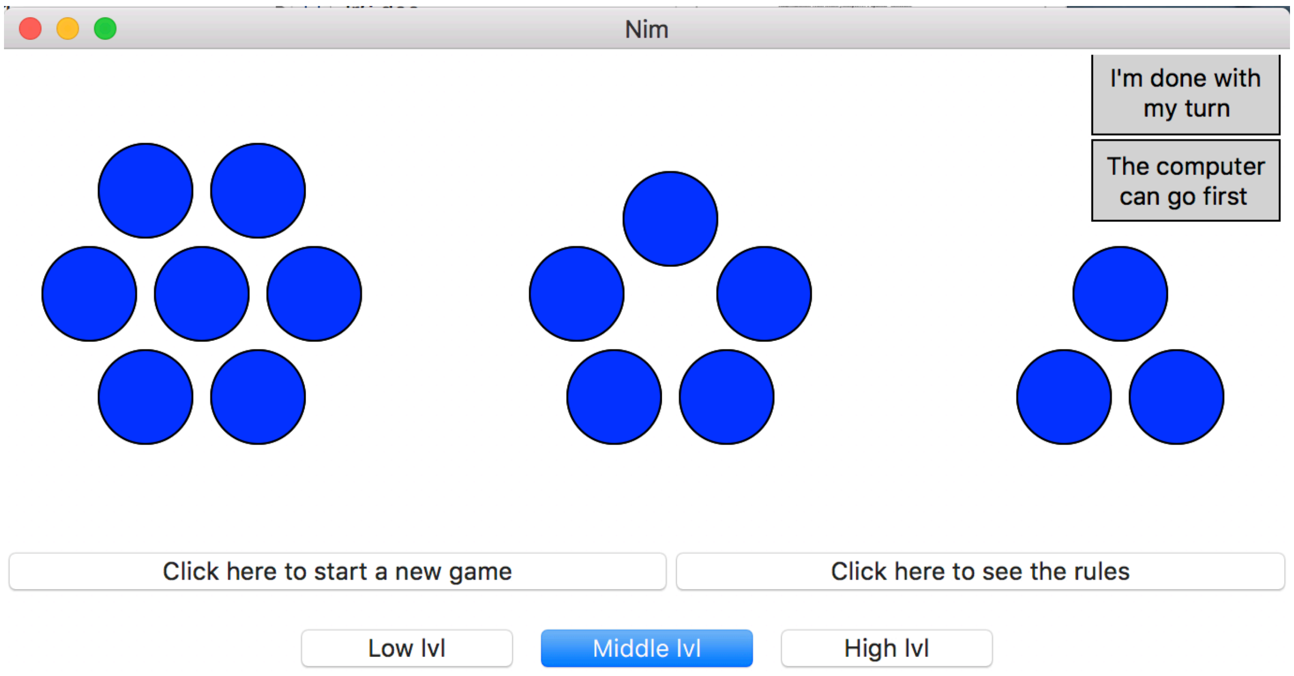


Рисунок 3.2


Nim
I'm done with my turn
The computer can go first
Click here to start a new game
Click here to see the rules
Low lvl
Middle lvl
High lvl

ВЫВОДЫ

В рамках данной лабораторной работы изучил математическую игру Ним и выполнил программную реализацию одной из его разновидностей.