ASSIGNMENT REPORT

Assignment ID: 1

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DESIGN - BDI paradigm

- *Belief*: data sensed from the environment

There is a parameter called `senseRatio`. The agent can sense the things (tiles, holes, obstacles, homes) of the environment under this ratio.

- *Desire*: options from which the agent can choose to attain the goal.
  - option1: pick up a tile.
  - option2: fill a hole.
  - option3: find tiles.
  - option4: find holes.
  - option5: go to the home.
- *Intention*: actions that the agent will take.
  - plan1:

    ```
    {
        NAME: "pick up a tile"
        GOAL:
            ACHIEVE CARRY $TILE
        CONTEXT:
        BODY:
            EXECUTE CHOOSE $TILE
            EXECUTE PICK $TILE
            ACHIEVE CARRY $TILE
        FAILURE:
            EXECUTE print "== Pick failed! =="
    }
    ```

  - plan2:

```
{
    NAME: "fill a hole"
    GOAL:
        ACHIEVE FILL $HOLE
    CONTEXT:
        FACT CARRY $TILE
    BODY:
        EXECUTE CHOOSE $HOLE
        EXECUTE REMOVE $TILE
        ACHIEVE FILL $HOLE
    FAILURE:
        EXECUTE print "== Fill failed! =="
}
```

- plan3:

```
{
    NAME: "find tiles"
    GOAL:
        ACHIEVE FIND $TILE
    CONTEXT:
        FACT EMPTY $TILE
    BODY:
        EXECUTE SENSE environment
        WHEN: TEST (> $TILE 0) {
            ACHIEVE FIND $TILE
        } ELSE TEST (> $ENERGY 0) {
            EXECUTE MOVE
            EXECUTE REDUCE $ENERGY 1
        }
    FAILURE:
        EXECUTE print "== Find tiles failed! =="
}
```

- plan4:

```
{
    NAME: "find holes"
    GOAL:
        ACHIEVE FIND $HOLE
    CONTEXT:
        FACT CARRY $TILE
    BODY:
        EXECUTE SENSE environment
        WHEN: TEST (> $HOLE 0) {
            ACHIEVE FIND $HOLE
        } ELSE TEST (> $ENERGY 0) {
            EXECUTE MOVE
            EXECUTE REDUCE $ENERGY 1
        }
    FAILURE:
        EXECUTE print "== Find holes failed! =="
}
```

- plan5:

```
{
    NAME: "go to the home"
    GOAL:
        ACHIEVE REFUEL
    CONTEXT:
        FACT <= $ENERGY $THRESHOLD
    BODY:
        EXECUTE SENSE_GLOBALLY environment
        LOOP: TEST (> $ENERGY 0 and not_reach_home) {
            EXECUTE MOVE
            EXECUTE REDUCE $ENERGY 1
        }
        ACHIEVE REFUEL
    FAILURE:
        EXECUTE print "== Go to the home failed! =="
}
```

DESIGN - Implement Details

Step

At every interval, the agent will choose one of the plans depending on the current inner state and the outer environment.

1. The agent will sense the environment.
    i. If there are some tiles at current location, then the agent will pick up the tile.
    ii. Else if there are some holes at current location and the agent is carrying some tiles, then the agent will fill the hole.
    iii. Otherwise,
        a. If the energy is not enough (less than the threshold), then the agent needs to change the target and head to home first.
        b. Else if there is no tile carried, then the agent will go to find a tile.
        c. Otherwise, the agent will find a hole to fill.

```java
    @ScheduledMethod(start=1, interval=1)
    public void step() {
        System.out.println("At "+grid.getLocation(this));

        // reset target when refreshing. Not practical
//      double tick = RunEnvironment.getInstance().getCurrentSchedule().getTickCount();
//      if (tick % changeInterval == 0.0) {
//          targetPt = null;
//      }

        // try picking up a tile or filling a hole at current location
        // try picking first then filling. The short circuit of '&&' will make it.
        // if there is no tile to pick up or no tile to pick up, then move
        if (!pickTile() && !fillHole()) {
            if (energy <= energyThreshold) {
                // if energy is lower than threshold, then it needs to refuel at home
                if (!headingHome) {
                    targetPt = findHomeSpot();
                    headingHome = true;
                }
                System.out.println("Heading to home at "+targetPt);
                if(moveTowards(targetPt)) {
                    targetPt = null;
                    // refuel
                    energy = startingEnergy;
                    headingHome = false;
                }
            } else if(targetPt != null) {
                System.out.println("Heading to target at "+targetPt);
                // continue moving to target
                if(moveTowards(targetPt)) {
                    targetPt = null;
                }
            } else if (tilesCarried.isEmpty()) {
                // if not taking a tile, find and pick one
                targetPt = findTileSpot();
                System.out.println("Found tile at "+targetPt);
                // move and pick tile
                if(moveTowards(targetPt)) {
                    System.out.println("Succeed in finding a tile.");
                    targetPt = null;
                    pickTile();
                }
            } else {
                // if already taken a tile, find and fill the hole
                targetPt = findHoleSpotStatic();
                System.out.println("Found hole at "+targetPt);
                // move and fill hole
                if(moveTowards(targetPt)) {
                    System.out.println("Succeed in finding a hole.");
                    targetPt = null;
                    fillHole();
                }
            }
        }

        System.out.print("Agent "+this.id+", score: "+this.score+", energy: "+this.energy+", tiles: "+this.tilesCarried.size()+" \n\n");
    }
```

Move

Path

The agent must know how to reach the target as quickly as possible, i.e., it must run along the shortest path. Here I used two kinds of strategies to solve this problem.

1. If the target is not under the sense ratio, then the agent will move to the point that has the nearest straight line distance to the target.
2. If the target is under the sense ratio, then the agent will go along the path calculated by `A* algorithm`.

`A* algorithm` is a kind of heuristic search, where the agent will find the reachable path with least cost. Its rule is to minimize the following value.

$$f(n) = g(n) + h(n)$$

where `g(n)` is the cost from the start point to the next point `n`, and `h(n)` is the heuristic function that estimates the cost from the next point `n` to the goal point. Here the heuristic function is the straight line distance from the next point to the goal point.

Obstacle

But how to prevent the influence of obstacles? There are two methods to solve this problem.

1. Using a variable called `lastPt` to record the last point that the agent has passed. The agent will never choose `lastPt` as its next point to move.

The first case of Tileworld is shown as below. The agent is at E3, the target is at A3, and there are obstacles at C2, C3, C4. According to the action described above, the agent will move to D3, then D4 (or D2, symmetrically). If `lastPt` does not exist, the agent will then move to D3 since D3 has the shortest straight line distance to the target (A3). However, thanks to `lastPt` , this choice is filtered and the agent will move to C5, the second nearest point.

	1	2	3	4	5
A			TP		
B					
C		OB	OB	OB	
D					
E			AG		

	1	2	3	4	5
A			TP		
B					
C		OB	OB	OB	(AG, next)
D			x=lastPt	AG	
E			x		

1. Using `A* algorithm` to bypass the obstacles.

The second case of Tileworld is shown as below. The difference is that the obstacle is asymmetric and its one side is touching the boundary of the world.

	1	2	3	4	5
A			TP		
B					
C		OB	OB	OB	OB
D					
E			AG		

The agent will first move to D3 and then to D2 (or D4 since both have the same shortest straight line distance to the target). However, at next time, since C1 is nearer to the target than D5, the algorithm will choose the path E3-D3-D2-C1 instead of E3-D3-D4-D5, which make it possible to bypass the obstacles.

	1	2	3	4	5
A			TP		
B					
C		OB	OB	OB	OB
D			x1=lastPt	AG	(AG, next)
E			x1		

	1	2	3	4	5
A			TP		
B					
C	(AG, next)	OB	OB	OB	OB
D		AG	x2=lastPt		

	1	2	3	4	5
E			x2		

```java
/**
 * move towards the point
 * one distance a time
 * return true if it has reached the point; otherwise, false.
 * */
public boolean moveTowards(GridPoint targetPt) {
    // if no target, then stay still
    // return true to make it re-choose the target at next tick
    if (targetPt == null) {
        return true;
    }

    GridPoint thisPt = grid.getLocation(this);
    // if no energy, it cannot move
    if (energy <= 0) {
        return thisPt.equals(targetPt);
    }

    // not reached the target
    if (!thisPt.equals(targetPt)) {
        // find the legal points around
        List<GridCell<Obstacle>> nghCells = getThisGridNeighbour(Obstacle.class, false, moveRatio, moveRatio);
        List<GridPoint> nghLegalPts = nghCells.stream()
                .filter(cell -> cell.size() <= 0)
                .map(cell -> cell.getPoint())
                .filter(point -> !point.equals(thisPt) && !point.equals(lastPt))
                .toList();

        // if surrounded by the obstacle, then stay still
        // return false to keep target and make agent wait to the environment to refresh
        if (nghLegalPts.isEmpty()) {
            return false;
        }

        List<GridCell<Obstacle>> senseCells = getThisGridNeighbour(Obstacle.class, false, senseRatio, senseRatio);
        List<GridPoint> senseLegalPts = senseCells.stream()
                .filter(cell -> cell.size() <= 0)
                .map(cell -> cell.getPoint())
                .filter(point -> !point.equals(thisPt) && !point.equals(lastPt))
                .toList();

        boolean hasSensedTarget = senseLegalPts.stream().filter(pt -> targetPt.equals(pt)).toList().size() > 0;
        // if target under the senseRatio, then the agent can directly move to it; otherwise, move to the around point that nearest to target
        GridPoint nextPoint = hasSensedTarget ?
                shortestPath(thisPt, targetPt).get(1) :
                Collections.min(nghLegalPts, (p1, p2) -> (int)(grid.getDistance(p1, targetPt) - grid.getDistance(p2, targetPt)));

        // record last passed point
        lastPt = thisPt;

        System.out.println("Next move to " + nextPoint);
        moveTo(nextPoint);
        // decrease energy after moving
        this.energy--;

        return grid.getLocation(this).equals(targetPt);
    }
    return true;
}
```

Oscillation

Apart from the obstacles, the oscillation of the agent is also a problem. Suppose the Tileword is as blow.

	1	2	3	4	5
A					
B					
C			OB	AG	
D					
E					

When there is no hole or no tile under the range of sense ratio, the agent will move randomly. Therfore, the grids (except obstacles) around the agent are all the possible choices and the agent may oscillate between these grids. As shown below, the agent may move around the obstacle or between two grids.

	1	2	3	4	5
A					
B			(AG, next)		
C		(AG, next')	OB	AG, (AG, next''')	
D			(AG, next'')		
E					

	1	2	3	4	5
A					
B			(AG, next), (AG, next'')		
C			OB	AG, (AG, next')	
D					
E					

To solve this problem, there is a queue `passedPts` to record the points which the agent has been to. This queue has a fixed size. When the agent passes a point, it will check if the point is in the queue. If it is, then the agent will increase its cost. Otherwise, the agent will record this point with 1 cost and pop out the head of the queue if the queue's size is larger than the fixed size. When choosing the next point to move to, the agent will also filter the queue's points with cost larger than the threshold. Emperically, I used (size, threshold) = (3, 2).

```
public class FixedSizeQueue {
    private int size;
    private int threshold;
    private List<PointWithCost> queue;

    public FixedSizeQueue(int size, int threshold) {
        this.size = size;
        this.threshold = threshold;
        this.queue = new ArrayList<>();
    }

    public void offer(GridPoint pt) {
        PointWithCost pwc = new PointWithCost(pt, 1);
        int idx = this.queue.indexOf(pwc);
        if (idx == -1) {
            this.queue.add(pwc);
        } else {
            this.queue.get(idx).cost++;
        }
        if (this.queue.size() > size) {
            this.queue.remove(0);
        }
    }

    public PointWithCost poll() {
        return this.queue.remove(0);
    }

    public boolean contains(GridPoint pt) {
        for (PointWithCost pwc : queue) {
            if (pwc.cost >= threshold && pwc.pt.equals(pt)) {
                return true;
            }
        }
        return false;
    }
}
```

Holes history

Since the holes are static (only tiles and obstacles are dynamic), we can record the location of the history passed holes. When the agent has carried some tiles and is going to find holes to fill, it will first sense the environment. Once the agent has found some holes, it will record the location of the holes and return the spot with most holes. If the agent cannot find any holes, it will check the history of the passed holes and return the spot with nearest hole.

```
/**
 * find the hole
 * used when the holes are static
 * */
public GridPoint findHoleSpotStatic() {
    List<GridCell<Hole>> holeCells = getThisGridNeighbour(Hole.class, true, senseRatio, senseRatio);

    GridPoint thisPt = grid.getLocation(this);

    GridPoint holeSpot = null;
    int maxCount = -1;
    for (GridCell<Hole> cell : holeCells) {
        // store the location of the holes
        if (cell.size() > 0) {
            if (!this.holesFound.contains(cell.getPoint())) {
                this.holesFound.add(cell.getPoint());
            }
        }
        if (cell.size() > maxCount) {
            holeSpot = cell.getPoint();
            maxCount = cell.size();
        } else if (cell.size() == maxCount && maxCount > 0) {
            if (grid.getDistance(thisPt, holeSpot) > grid.getDistance(thisPt, cell.getPoint())) {
                holeSpot = cell.getPoint();
            }
        }
    }

    // no hole found in senseRatio.
    // instead of randomly moving, move to the hole found before
    if (maxCount == 0 && !this.holesFound.isEmpty()) {
        if (holesFound.size() > 1) {
            holesFound.sort((hole1, hole2) ->
                (int)(grid.getDistance(thisPt, hole1)-grid.getDistance(thisPt, hole2))
            );
        }
        holeSpot = holesFound.get(0);
    }

    return holeSpot;
}
```

Record the information

I wrote some codes to collect the information of the simulation, such as the size and object counts of the environment, the score and energy of the agent at specific tick. The collector will start when the simulation begins, and will write the information into a `.csv` file when the simulation stops.

Actually, the output file does not follow the standard form of `.csv`. I have modified its structure in order to show as much information as possible while keeping it readable.

The first two lines are the global data. Here is the description.

simName	height	width	agentCount	holeCount	tileCount	homeCount	obstacleCount	energy	changeInterva
the name of this simulation	the height of environment	the width of environment	number of agents	number of holes	number of tiles	number of homes	number of obstacles	the starting energy of an agent	the frequency that the environment changes

Then after an empty line, there are the preserved information of the agents, group by tick. Here is the description.

tick	agent	score	energy	location	target
The simulation tick from starting, or interval	agent id	score of the agent	current energy of the agent	agent location point	the destination point for next move

RUNNING RESULT - Simulation

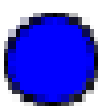
The parameters and simulation results can be seen in the source code files. Following are the icons indicating the characters.


refers to the home, which is used to refuel.


refers to the hole.


refers to the tile.


refers to the obstacle.

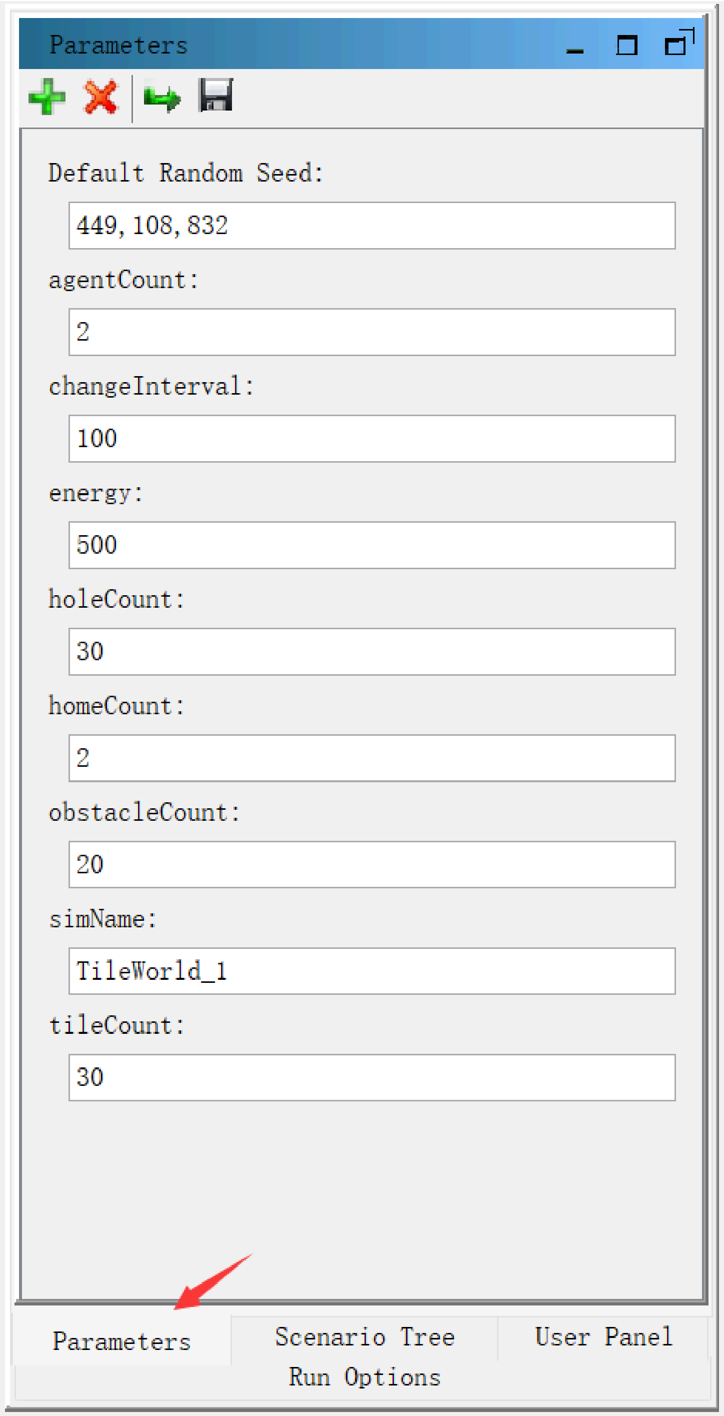

refers to the agent.

Setting parameters

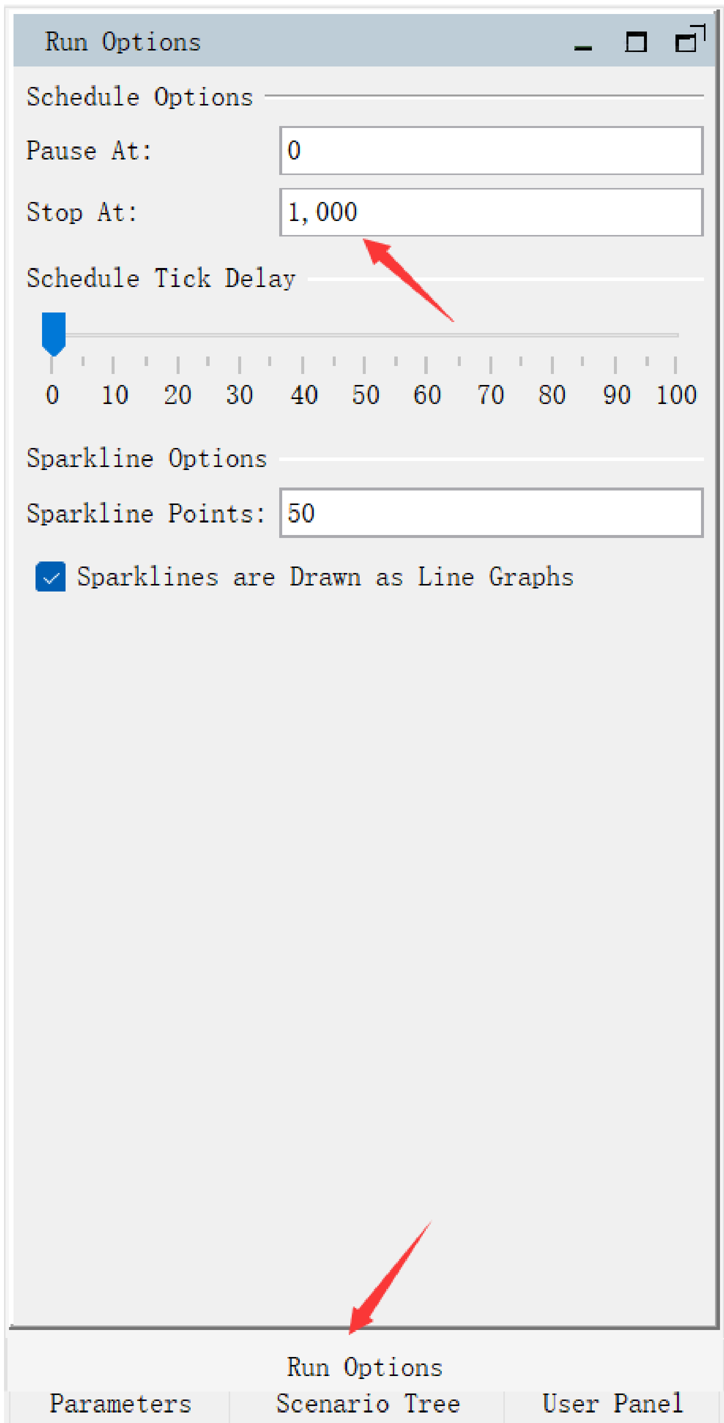
The parameters can be set in the simulation runtime GUI. Here is the meaning of the parameters.

parameter	meaning
simName	the name of this simulation
changeInterval	the frequency that the environment changes
agentCount	number of agents
tileCount	number of tiles
holeCount	number of holes
homeCount	number of homes
obstacleCount	number of obstacles

parameter	meaning
energy	the starting energy of an agent



Meanwhile, the stop tick of the simulation can be set here.



Following are the fixed parameters for every simulation.

parameter	value
environment size	(height, width) = (50, 100)
number of intervals to change	100
stop tick	1000

Structure of the source code files

The source code files are under the folder `src_code` . And its structure and descriptions are as below.

```
src_code
    ├─records           // simulation records
    ├─src               // source code
    │  └─tileWorld
    └─TileWorld.rs      // styles and parameters
```

PROBLEMS

Eclipse is hard to use. But there is no support for IDEA or vscode due to the integration of Eclipse according to the developers' response.