02285 AI and MAS, SP19
Exercises for week 7, 19/3-19

Exercise 1 (Multi-Agent Coordination and Manual Client)

a) First download and unzip the archive `manualclient.zip`. All levels mentioned below are provided in the directory `levels` of this archive. Now read the manual of the manual client that is to be used in this exercise, `manualclient.pdf`. Then try it out in your group, first running it locally on the level `MAs063430`. You should try to solve the level with each group member controlling at most one agent. Then try to solve the level `MASojourner` in the same manner, but using the client in webserver mode. If you are less than 4 students in your group, join forces with another group for `MASojourner`.

b) Consider the single-agent level `simple_coord_one_agent` in Figure 1. What is the length of a shortest solution to this problem (fewest number of actions to solve the level)? You can check your answer by running BFS from the Warmup Assignment on the level.

c) Consider now the two-agent version of the level, `simple_coord`, in Figure 2. The solution from the previous question is still valid, but a shorter solution can be found by the two agents collaborating. What is now the length of a shortest solution (fewest number of joint actions to solve the level)? You can first try to solve it via playing the following small game in your group (inspired by Ricochet Robots): Take 5 minutes where everyone in the group individually tries to find the shortest possible solution. The initial solution is the single-agent solution from the previous question. Whenever someone believes to have a shorter solution, that persons says the number of joint actions of the solution out loud. This continues until the 5 minutes are up. The player who wins is the one who has said the lowest number that turned out to be correct when afterwards checking the solution.

After playing the game, check that you have indeed found a shortest solution. You can e.g. try it out with the manual client to make it easier to explore and

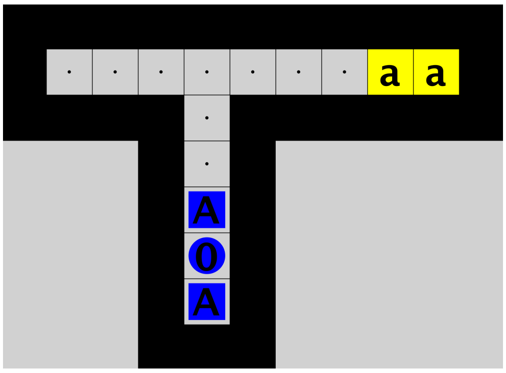

Figure 1: `simple_coord_one_agent`

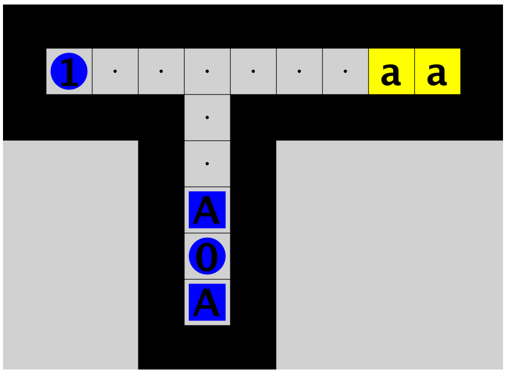

Figure 2: `simple_coord`

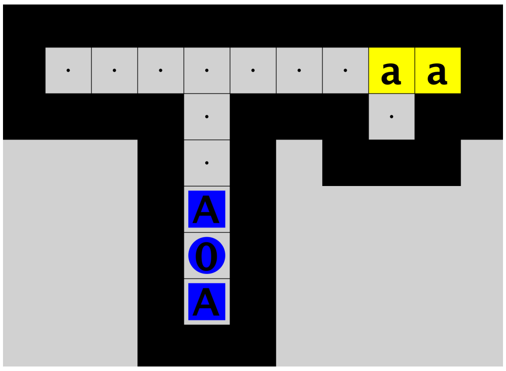

Figure 3: `simple_coord_one_agent2`

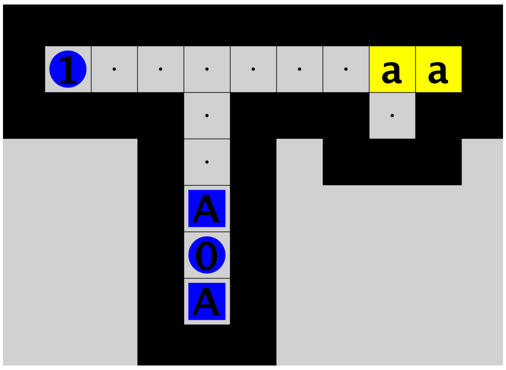

Figure 4: `simple_coord2`

count the number of joint actions in the different possible solutions (but do note that sometimes you have to make more than one keystroke per action).

d) Consider the alternative level versions shown in Figures 3–4. What are now the lengths of shortest solutions?

e) Assume the level from the previous question is to be solved by a multi-agent system, where each agent decides on its own actions. What kind of coordination is required between the two agents in order to guarantee an optimal (shortest) solution? Do they need social laws? Communication? Do they need to negotiate about or agree on a plan in advance?

f) Now consider the two-agent level in Figure 5. What is the length of an optimal solution? Assume as in the previous question that the level is to be solved by a multi-agent system, where each agent decides on its own actions. What kind of coordination is required between the two agents in

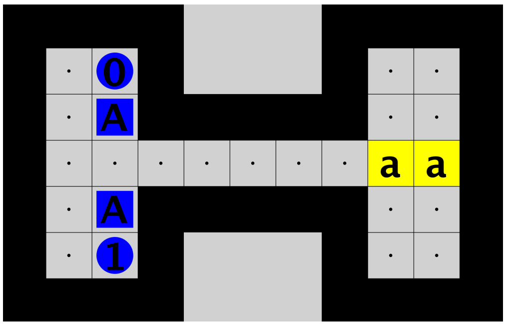

Figure 5: `who_goes_first`

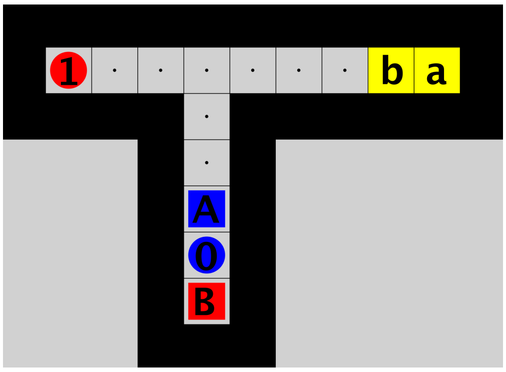

Figure 6: `simple_coord_colors`

order to guarantee the optimal (shortest) solution? Do they need social laws? Communication? Do they need to negotiate about or agree on a plan in advance?

g) Consider the level in Figure 6. The colors impose a clear task sharing between the two agents. Assume the two agents initially only plan for their own subtask (getting their own box to the goal), not considering the goal or plan of the other agent. What kind of communication is then required between the agents to ensure coordination (ensuring that the goal will eventually be reached). You can try to seek inspiration in the FIPA Agent Communication Language (see slides). Think both about what kind of performative and what kind of content is needed in those speech acts.

h) Consider the level `all_blues` in Figure 7. First you should try to solve it in your group using the manual client in webserver mode, with one student controlling each agent, and *without any form of communication whatsoever between you*. If you are fewer than 4 people in your group, join forces with another group (the same holds for the levels considered further below, where some of them have up to 8 agents). When solving the level without communication, how much did you employ plan recognition to ensure coordination: reasoning about the other agents' plans/goals/intentions/strategies? Now try to solve the level again, but this time allowing communication (requesting, informing, etc.). Did it become significantly simpler? Would it be possible to implement a multi-agent system employing communication similar to the one you engaged in?

i) Now try to solve as many of the following levels as possible with one student controlling each agent:

   (1) `MAs092730`

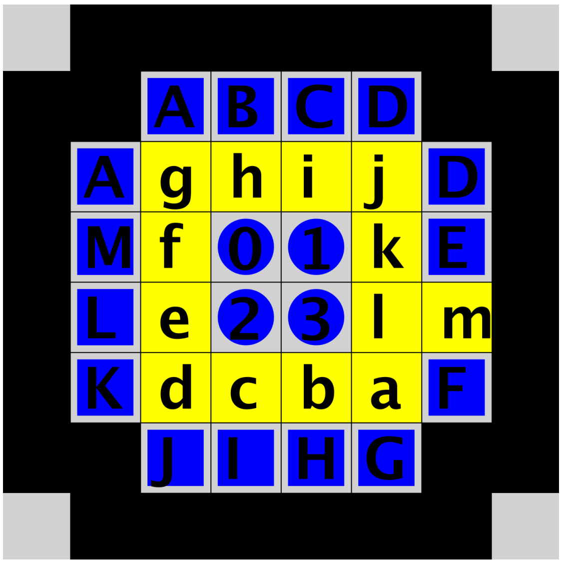

Figure 7: `all_blues`

(2) `MAsimple2`

(3) `MAsimple5`

(4) `MAs062421`

(5) `MAPinkPanthers`

(6) `MAbruteforce`

(7) `MADinMor`

(8) `MAAIGroup01`

(9) `MAschwenke`

(10) `MADilemma`

(11) `MAchallenge`

(12) `MAs072442`

(13) `MAma2`

(14) `MAHumans`

(15) `MAPHOBAR`

(16) `MAAlpha`

(17) `MATheFence`

For each level, try to discuss how it would be possible to design a multi-agent system to solve that (and similar) levels. This includes discussions of:

Task sharing Is explicit communication/negotiation/agreement on who does what necessary?

Conflict resolution Assuming initial task sharing has been completed, e.g. the obvious color-based task sharing in levels where all agents have distinct colors. What conflicts can arise if all agents only plan for their own subtasks, ignoring the other agents? How difficult is it to solve these conflicts? E.g. in simple cases it might be sufficient with a social law that forces an agent to wait until a non-consumable resource currently in use by another agent is freed. In more complicated cases, some kind of explicit communication/coordination/negotiation might be needed. Difficult conflicts can also be resolved by multi-body planning like in the Martha project.

Communication What kind of communication is needed (or advantageous) to solve the level? Could this communication be formalised and be made part of a multi-agent systems to solve such levels?

Hopefully these discussions can inspire you in your design of a solution to the programming project.