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Fachgruppe Algorithmen und Komplexität
Projektgruppe Schlaue Schwärme



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User's Guide

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1 Introduction

This document shall help you to use the `RobotSwarmSimulator` to simulate robot swarms and to get useful information by the visualization and statistics modules.

For this purpose the document is divided in several sections. It will be useful if you just start this the "Getting Started!" section play a little bit with the simulator and continue with reading the more detailed information on input parameters, input-file specifications, generating simulations and getting statistics.

2 Getting Started

For trial use of `RobotSwarmSimulator` you can simply run generation mode, load one of our default algorithms and see how the robots are moving in the space. All example files can be found in subdirectory `ProjectFiles`. Here we will present a short example how to simulate the behavior of the `CENTEROFGRAVITY` algorithm (COG).

1. Create a new directory "mytest" to keep all avoid unwanted output files everywhere in your system.
2. Copy file `cog.lua` to this directory.
3. Run `<path to RSS>/RobotSwarmSimulator -generate -distr-pos=20 -algorithm=cog.lua` and the the following files are being generated:
 - `newrandom.swarm` – here you can edit all global information
 - `newrandom.robot` – here you can edit the robots
 - `newrandom.obstacle` – here you can add obstacles
4. Run `<path to RSS>/RobotSwarmSimulator -project-file=newrandom` and see the simulation works. You can stop the simulation by pressing `Q`.
5. A new statistics file called **TODO** which name? has been generated in your working directory. You can run `gnuplot` to get charts.

This simple test can be used as base for further tests. Please look at the following chapters to get specifications of the input-files and the user's interface.

3 Running the RobotSwarmSimulatorwith Parameters

TODO describe the package structure

The RobotSwarmSimulator exists as executable for Linux, MacOS and Windows in the corresponding directories. Each execution of the RobotSwarmSimulator needs specific parameters that are mandatory. By running the RobotSwarmSimulator you have to specify at least, which kind of execution do you want. By adding the parameter `--generate` the generation mode is started to create new input-files. On the other side by adding the parameter `--project-file=<your input>` the common simulation mode is started. Also a run with special parameters like `--help` or `--about` is possible. Thus a typical runs look like:

```
./RobotSwarmSimulator --help
./RobotSwarmSimulator --project-file <path_to_testdata>/testfile_2
./RobotSwarmSimulator --project-file <path_to_testdata>/testfile_2
                        --history-length 10
./RobotSwarmSimulator --generate --distr-pos=17.0
```

All of the options listed in Listing 1 can be used. Further information for this parameters can be found in the following sections. The definition of most of the parameters can be found in Table 1.

Listing 1: RSS Helpline

```

1 General options:
2   --help           shows this help message
3   --version        shows version of RobotSwarmSimulator
4   --about          tells you who developed this awesome piece of software
5
6 Generator options:
7   --generate       switch to generator mode
8   --seed arg (=1)  seed for random number generator
9   --robots arg (=100) number of robots
10  --algorithm arg (=NONE) name of algorithm or lua-file
11  --worldfile arg (=newrandom) world-file for output
12  --robotfile arg (=newrandom) robot-file for output
13  --obstaclefile arg (=newrandom) obstacle-file for output
14  --distr-pos arg (=0) distribute position in cube [0;distr-pos]^3
15  --distr-vel arg (=0) distribute velocity in cube [0;distr-vel]^3
16  --distr-acc arg (=0) distribute acceleration in cube [0;distr-acc]^3
17  --distr-coord      distribute robot coordsystems uniformly
18
19 Simulation options:
20  --project-file arg Project file to load
21  --history-length arg (=25) history length

```

3.1 General options

--help Lists all possible options.

--version This option shows the version information of your RobotSwarmSimulator

--about Get information about the developer team, contact information and more.

3.2 Generator options

- generate** Switch to generator mode. This is necessary for the further options of this section.
- seed=arg** Sets the seed for the random number generator for robot generation. If not set the seed is 1, but you really should set this value. An unsigned integer value is expected.
- robots=arg** The number of robots to be generated. The default number is 100. An unsigned integer value is expected.
- algorithm=arg** The name of the algorithm the robots should use. If not set the algorithm `SimpleRobot` is used. This is only a stub without any functionality. Also the name of a lua-file can be given. Extension `.lua` is mandatory for lua-files.
- worldfile=arg** The name of the worldfile that shall be generated. Default is `newrandom`. File-name without extension is expected.
- robotfile=arg** The name of the robotfile that shall be generated. Default is `newrandom`. File-name without extension is expected.
- obstaclefile=arg** The name of the obstaclefile that shall be generated. Default is `newrandom`. File-name without extension is expected.
- distr-pos=arg** Distributes the position of robots uniformly at random in box of size $\text{arg} \times \text{arg} \times \text{arg}$. If not set, all robots are at position zero.
- distr-vel=arg** Distributes the velocity of robots uniformly at random by vectors in box of size $\text{arg} \times \text{arg} \times \text{arg}$. If not set, all velocities are zero.
- distr-acc=arg** Distributes the acceleration of robots uniformly at random by vectors in box of size $\text{arg} \times \text{arg} \times \text{arg}$. If not set, all velocities are zero.

3.3 General options

- project-file** Specifies the project file use. Do not add extension `.swarm`. Mandatory for simulation.
- history-length=arg** Sets the history length i.e. the length of the ringbuffer to store world-objects until they get visualized. Standard is 25. An unsigned integer is expected.

4 Using the Simulator-Interface

During the simulation it is possible to interact with the simulation in different ways. The following hot-keys are supported while simulation:

Space	Start/Stop
-------	------------

- Q** the Quit RobotSwarmSimulator
- F1** Help
- G** Show Center of all gravity of Swarm
- V** Show velocity vectors
- B** Show acceleration vectors
- K** Show global coordinates system
- W, A, S, D** In the corresponding camera mode use **W** for up and **S** for down
- Arrow-Keys** left, right, before, behind
- Mouse** Mouse for spinning
- +**, **-** increase/ decrease simulation-speed by constant
- ***, **/** double/ half simulation-speed
- C** Change camera

5 Robot Definitions by LUA-files

There are two ways to define a new robot. One way is hardcoded in the RobotSwarmSimulator the other way is to define the robots by scripting their behavior in the Lua scripting language. For example Listing 2 shows you how to formulate the COG-algorithm in Lua.

TODO yeah, how can I do this?



Listing 2: COG algorithm in Lua

```

1 function main()
2   robots = get_visible_robots();
3   center = get_position(get_own_identifier());
4   for i = 1, #robots do
5     center = center + get_position(robots[i]);
6   end
7   center = center / (#robots+1);
8   add_position_request(center);
9 end

```

6 Statistics

Durch die berechneten Statistiken werden zwei Dateien ausgegeben:

- gnuplot_20091224_184129_ALL.plt (GNUPlot-Konfigurationsdatei)

- `output_20091224_184129_ALL.plt` (zugehörige statistische Daten)
- `output_20091224_184129_DATADUMP_FULL.plt` (vollständiger Datendump)

Die Dateinamen ergeben sich aus dem aktuellen Datum (Jahr, Monat, Tag), sowie der Zeit (Stunden, Minuten, Sekunden), gefolgt von einer Bezeichnung der betrachteten Objektmenge (z.B. ALL, MASTERS, ... für jeden Eintrag in STATISTICS_SUBSETS wird ein eigenes solches Dateienpaar angelegt).

A Visualization with GNUPlot

Anzeige mit GNUPlot Zur Anzeige der Statistiken eines abgeschlossenen Simulationsdurchlaufes muss die entsprechende GNUPlot-Konfigurationsdatei mit GNUPlot geöffnet werden: Unter Unix-System kann man hierfür nach Aufruf von `$ gnuplot` die interaktive GNUPlot-Shell verwenden (`> load ■gnuplotfile.plt■`). Weitere Befehle mit `> help`. Alternativ kann man sich die Ausgabe direkt anzeigen lassen mittels Shellkommando `$ gnuplot -persist ■gnuplotfile.plt■`, wobei das `-persist` bewirkt, dass das Anzeigefenster auch nach Erstellen der Ausgabe geöffnet bleibt. Weitere Flags siehe `$ man gnuplot`.

Konfiguration der Anzeige Der Inhalt der Datei `output_20091224_184129_ALL.plt` könnte auszugsweise so aussehen:

# time	avg_spd	minball_x	(...)
0	9.2	20.5	
1	11.3	21.5	
4	9.1	21.9	
6	7.5	22.3	

Jede Zeile enthält die statistischen Daten zu einem bestimmten Zeitpunkt. Der Beginn einer neuen Spalte wird hierbei durch (mindestens) ein Leerzeichen gekennzeichnet. '#' leitet eine Kommentarzeile ein.

In der Datei `gnuplot_20091224_184129_ALL.plt` findet nun die Formatierung der Daten für die Anzeige statt und kann beliebig geändert werden:

```
# statistics of the simulation
#=====
set title ' SCHLAUE SCHWÄRME '
set xrange []
set yrange []
set grid
set pointsize 0.5
set xlabel 'time'
set ylabel ''
plot 'output_(...)_ALL.plt' using 1:2 title 'avg_spd' with linespoints, \
      'output_(...)_ALL.plt' using 1:3 title 'minball_x' with linespoints
```

Die Angaben haben folgende Bedeutung:

- `set title 'Titel'` erzeugt einen zentrierten Titel am oberen Teil der grafischen Darstellung.

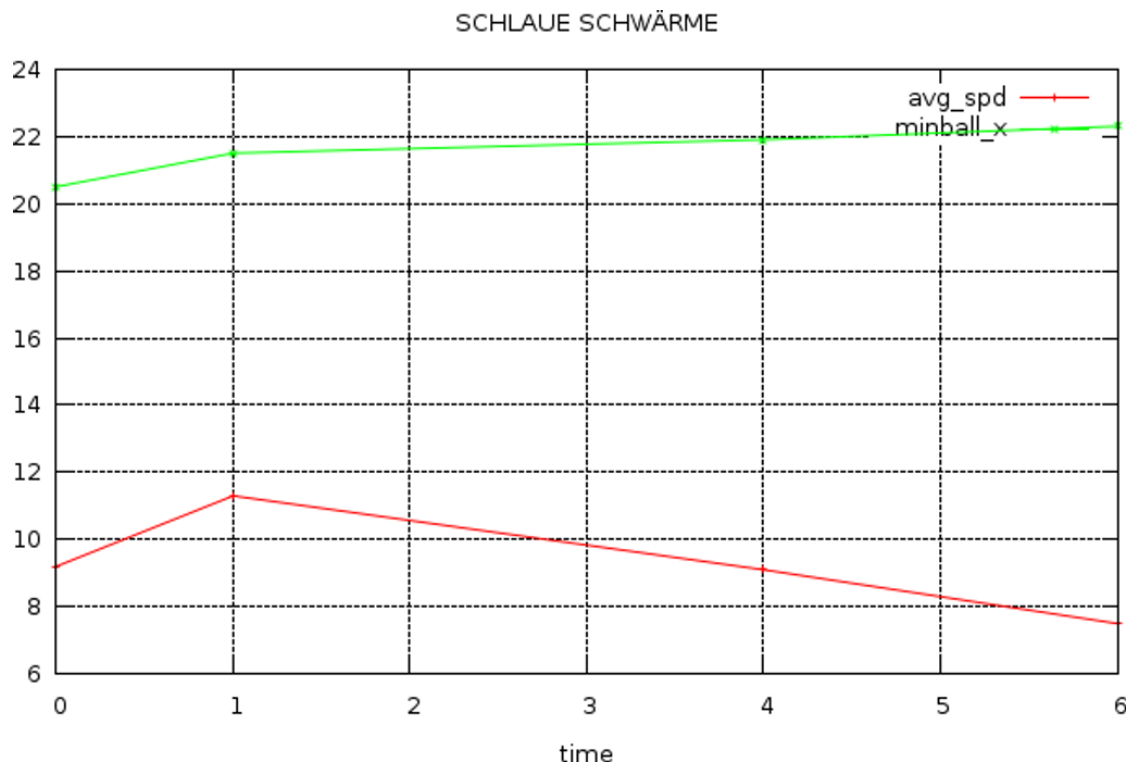
- `set xrange [min:max]` begrenzt den horizontal sichtbaren Bereich zwischen den Werten *min* und *max*, `set xrange []` führt diese Skalierung auf Grundlage der vorliegenden Daten automatisch durch.
- `set grid` blendet ein Gitternetz ein.
- `set pointsize multiplikator` skaliert die Größe der Punkte (falls eine Darstellung gewählt wird, welche Punkte beinhaltet) gemäß *multiplikator*.
- `xlabel 'Label'` beschriftet die X-Achse.

Diese Angaben beinhalten also *nur* grafische Aspekte, die z.B. für die Verwendung in Dokumentationen angepasst werden können. Die Einstellungen der anzuzeigenden Daten finden erst daraufhin statt:

- `plot 'Dateiname.plt'` leitet den tatsächlichen Vorgang der Darstellung ein. Hierbei werden die Daten aus der angegebenen Datei gelesen. Durch `using 1:2` werden die erste und die zweite Spalte gegeneinander dargestellt, wobei der erstgenannte Spaltenindex, also *time*, die X-Koordinate und folglich *avg_spd* die Y-Koordinate definiert. `title 'avg_speed'` fügt für die definierte Funktion einen Legendeneintrag mit dem Titel *avg_speed* hinzu. Der Zusatz `with linespoints` beschreibt die Darstellung durch mit Linien verbundene Zeichen an den Datenpunkten. `linespoints` kann auch ersetzt werden durch:
 - `lines` verbindet jeden Datenpunkt mit einer Linie
 - `dots` zeigt einzelne Punkte an (sinnvoll bei vielen Datenpunkten)
 - `points` fügt ein Zeichen an der Position des Datenpunktes ein. Die Größe kann durch den Befehl `set pointsize` geändert werden
 - `linespoints` erstellt gleichzeitig *points* und *lines*
 - `impulses` erzeugt eine vertikale Linie ausgehend von der X-Achse zum Datenpunkt

Zum Plotten einer weiteren Funktion in derselben Darstellung wird die gleiche Struktur durch ein Komma getrennt angehängen (auch aus verschiedenen Quelldateien). Dies ermöglicht auf einfache Art, dass die Darstellung der Statistiken unterschiedlicher Simulationsdurchläufe in einer Grafik dargestellt werden können.

Ergebnis



Weitere Informationen zu GNUPlot

- [1] offizielle Homepage: <http://www.gnuplot.info/>
- [2] Grundkurs: <http://userpage.fu-berlin.de/~voelker/gnuplotkurs/gnuplotkurs.html>

B Input-file Specifications

There are exactly four kinds of input files for the RobotSwarmSimulator. This includes the project specification files and also the Luascript-files that define the robot behaviour.

1. The main projectfile containing information about the model. The extension of this type of file is `".swarm"`.
2. A file containing robot information. The extension of this file is `".robot"`.
3. A file containing obstacle information. The extension of this file is `".obstacle"`.
4. Luafile that describes the robot behaviour. The extension of this file is `".lua"`.

B.1 Main projectfile

The following specifications hold only for the main projectfile (with extension `".swarm"`):

- A comment begins with a `'#'`.
- A line is a comment line (beginning with a `'#'`), an empty line or a line containing a variable followed by an equal sign followed by a *quoted* value of this variable. Example:

```
VAR_1="value"  
VAR_2 = "value"  
VAR_3= "value"  
VAR_4 ="value"
```

- a variable name has to be of the following form: `[A-Z0-9_]+`

B.1.1 Variables

The main project file contains the variables defined in table 1 and 2:

Variable name	Possible Values	Description	Default
PROJECT_NAME	String	Name of the project	-
COMPASS_MODEL	Still needs to be specified by the ASG-Team. For instance <code>NO_COMPASS</code>	Compass model	FULL_COMPASS
ROBOT_FILENAME	For instance <code>robot_file</code> . The extension of the file must not be appended in this variable.	Filename of the robotfile	same as project file
OBSTACLE_FILENAME	For instance <code>obstacle_file</code> . The extension of the file must not be appended in this variable.	Filename of the robotfile	same as project file
STATISTICS_SUBSETS	A concatenation of none or more of the following strings: <code>{ALL}</code> , <code>{ACTALL}</code> , <code>{INACTALL}</code> , <code>{MASTERS}</code> , <code>{ACTMASTERS}</code> , <code>{INACTMASTERS}</code> , <code>{SLAVES}</code> , <code>{ACTSLAVES}</code> , <code>{INACTSLAVES}</code>	Defines the subsets of all robots for which to calculate individual statistical data. E.g. “ <code>{ALL}</code> ” will produce statistical information on <i>all</i> robots as well as on <i>masters only</i>	NONE
STATISTICS_TEMPLATE	One of the following: “ALL”, “BASIC” or “NONE”	Identifies the set of informations to calculate for each subset.	ALL
STATISTICS_DATADUMP	Either “FULL” or “NONE”	Whether or not detailed information (e.g. all robots positions at each event) should be streamed to a file during simulation.	NONE
ASG		Type of ASG	SYNCHRONOUS
ASYNCHRONOUS_SEED	SYNCHRONOUS, ASYNCHRONOUS or SEMISYNCHRONOUS unsigned int	Seed for asynchronous ASG, only set if ASG=ASYNCHRONOUS	-
ASYNCHRONOUS_PART_P	double	Participation Probability for asynch ASG, only set if ASG = ASYNCHRONOUS	-
ASYNCHRONOUS_TIME_P	double	parameter governing the timing of asynch ASG, only set if ASG = ASYNCHRONOUS	-
ROBOT_CONTROL	see section B.1.3	RobotControl to use	-

Table 1: Variables in the main project file

Variable name	Possible Values	Description	Default
MARKER_REQUEST_HANDLER_TYPE	element from {STANDARD, NONE}	Type of Marker Request Handler to use	{NONE}
TYPE_CHANGE_REQUEST_HANDLER_TYPE	element from {STANDARD, NONE}	Type of Type Change Request Handler to use.	{NONE}
POSITION_REQUEST_HANDLER_TYPE	element from {VECTOR, NONE}	Type of Position Request Handler to use	{NONE}
VELOCITY_REQUEST_HANDLER_TYPE	element from {VECTOR, NONE}	Type of Velocity Request Handler to use	{NONE}
ACCELERATION_REQUEST_HANDLER_TYPE	element from {VECTOR, NONE}	Type of Acceleration Request Handler to use	v
MARKER_REQUEST_HANDLER_SEED	integer	Seed for Marker Request Handler to use	{NONE}
TYPE_CHANGE_REQUEST_HANDLER_SEED	integer	Seed for Type Change Request Handler to use.	-
POSITION_REQUEST_HANDLER_SEED	integer	Seed for Position Request Handler to use	-
VELOCITY_REQUEST_HANDLER_SEED	integer	Seed for Velocity Request Handler to use	-
ACCELERATION_REQUEST_HANDLER_SEED	integer	Seed for Acceleration Request Handler to use	-
MARKER_REQUEST_HANDLER_DISCARD_PROB	element from interval [0, 1]	Discard probability for Marker Request Handler to use	-
TYPE_CHANGE_REQUEST_HANDLER_DISCARD_PROB	element from interval [0, 1]	Discard probability for Type Change Request Handler to use.	-
POSITION_REQUEST_HANDLER_DISCARD_PROB	element from interval [0, 1]	Discard probability for Position Request Handler to use	-
VELOCITY_REQUEST_HANDLER_DISCARD_PROB	element from interval [0, 1]	Discard probability for Velocity Request Handler to use	-
ACCELERATION_REQUEST_HANDLER_DISCARD_PROB	element from interval [0, 1]	Discard probability for Acceleration Request Handler to use	-
POSITION_REQUEST_HANDLER_MODIFIER	list of vector modifiers (see B.1.2)	List of vector modifiers for Position Request Handler to use	-
VELOCITY_REQUEST_HANDLER_MODIFIER	list of vector modifiers (see B.1.2)	List of vector modifiers for Velocity Request Handler to use	-
ACCELERATION_REQUEST_HANDLER_MODIFIER	list of vector modifiers (see B.1.2)	List of vector modifiers for Acceleration Request Handler to use	-

Table 2: Variables in the main project file

Additional restrictions and information:

- The order of the variables in the main project file is not important.
- If a variable does not appear in the main projectfile, then its default value will be used if such a default value does exist (otherwise an exception will be thrown while loading the main project-file).

B.1.2 Vector Modifiers

The list of vector modifiers is a (not necessarily nonempty) list, i. e.

`(VECTOR_MODIFIER_1);(VECTOR_MODIFIER_2);...`

The order of the elements of this list is important. If no Vector Modifier shall be used for the corresponding Request Handler, then use `VECTOR_MODIFIERS=""`.

An element `VECTOR_MODIFIER_k` of the Vector Modifier list is a tuple, defined as follows:

`VECTOR_MODIFIER_k=(VECTOR_MODIFIER_TYPE,VECTOR_MODIFIER_PARAM_1,VECTOR_MODIFIER_PARAM_2,...)`

The number and types of parameters `VECTOR_MODIFIER_PARAM_1, VECTOR_MODIFIER_PARAM_2, ...` depends on the corresponding type of the Vector Modifier. Currently there are the following types of Vector Modifiers:

- `VectorDifferenceTrimmer`
- `VectorTrimmer`
- `VectorRandomizer`

I. e. $\text{VECTOR_MODIFIER_TYPE} \in \{\text{VECTOR_DIFFERENCE_TRIMMER}, \text{VECTOR_TRIMMER}, \text{VECTOR_RANDOMIZER}\}$

If `VECTOR_MODIFIER_TYPE=VECTOR_DIFFERENCE_TRIMMER`, then the following parameters are expected:

1. length of type double

I. e. an element of the `VECTOR_MODIFIERS`-list of type `VECTOR_DIFFERENCE_TRIMMER` may look like: `(VECTOR_DIFFERENCE_TRIMMER, 5.2)`.

If `VECTOR_MODIFIER_TYPE=VECTOR_TRIMMER`, then the following parameters are expected:

1. length of type double

I. e. an element of the `VECTOR_MODIFIERS`-list of type `VECTOR_TRIMMER` may look like: `(VECTOR_TRIMMER, 10.0)`.

If `VECTOR_MODIFIER_TYPE=VECTOR_RANDOMIZER`, then the following parameters are expected:

1. seed of type unsigned int
2. standard derivation of type double

I. e. an element of the `VECTOR_MODIFIERS`-list of type `VECTOR_DIFFERENCE_TRIMMER` may look like: `(VECTOR_DIFFERENCE_TRIMMER,1,0.5)`.

B.1.3 RobotControl

The `RobotControl` variable defines the class which should be used to control the robots (and in particular to control the views of the robots). Currently one of the following classes has been chosen:

1. `UNIFORM_ROBOT_CONTROL`
2. `ROBOT_TYPE_ROBOT_CONTROL`

Each class is explained in detail below. Note that each class expects certain class specific parameters.

UniformRobotControl This class assigns each robot the same view type. The concrete view type needs to be defined using a `VIEW` variable. The possible values for this variable (view types) are defined below (see B.1.4). E.g. you may assign each robot global view to the world using `ROBOT_TYPE_ROBOT_CONTROL="GLOBAL_VIEW"`.

RobotTypeRobotControl This class assigns each robot type the same view type. Therefore robots with different robot types may have different view types. Currently there are two robot types:

1. `MASTER`
2. `SLAVE`

To specify which view type should be used by each robot type, there must be variables of the form *RobotType_VIEW*.

The value of each variable has to be a view type (see B.1.4). Note that the view type parameters are also distinguished using the *RobotType* prefix. E.g. you may specify

```
MASTER_VIEW="CHAIN_VIEW"
MASTER_CHAIN_VIEW_NUM_ROBOTS="5"
```

to set the view for master robots to a chain view allowing the robots to see five neighbor robots. Note that exactly one view type should be defined for each robot type.

B.1.4 ViewTypes

The view type of a robot defines its vision model. Whenever a view type is expected you may use one of the following values:

1. `GLOBAL_VIEW`
2. `COG_VIEW`
3. `CHAIN_VIEW`
4. `ONE_POINT_FORMATION_VIEW`
5. `SELF_VIEW`

Each view type is explained in detail below.

GLOBAL_VIEW Allows robots to see literally everything. There are no parameters expected.

COG_VIEW View model meant to be used for center of gravity algorithms, i.e. every robot can see every other robots position, velocity and acceleration. The coordinate-system and id of each robot is not visible. There are no parameters expected.

SELF_VIEW View model which allows robots to access every self-related information while disallowing to access any other information. There are no parameters expected.

CHAIN_VIEW View model meant to be used for robot chain related algorithms, i.e. every robot can see k neighbor robots position. Besides this no more information is visible. When using this view type you have to specify the variable $k \in \mathbb{N}$ using the parameter variable `CHAIN_VIEW_NUM_ROBOTS`.

ONE_POINT_FORMATION_VIEW View model meant to be used for one point formation algorithms, i.e. every robot can see every other robots position, velocity and acceleration only in a limited view radius r . The coordinate-system and id of each robot is not visible. When using this view type you have to specify the variable $r \in \mathbb{R}$ using the parameter variable `ONE_POINT_FORMATION_VIEW_RADIUS`.

B.1.5 Example of a main project file

A main project file may look like:

```

1  #
2  # Description about configuration.
3  #
4
5  PROJECT_NAME="My Exciting Project"
6  COMPASS_MODEL="NO_COMPASS"
7  ROBOT_FILENAME="myrobots"
8  OBSTACLE_FILENAME="myobstacle"
9  STATISTICS_MODULE="0"
10 ASG="ASYNCHRONOUS"
11 ROBOT_CONTROL="ROBOT_TYPE_ROBOT_CONTROL"
12 MASTER_VIEW="GLOBAL_VIEW"
13 SLAVE_VIEW="ONE_POINT_FORMATION_VIEW"
14 SLAVE_ONE_POINT_FORMATION_VIEW_RADIUS="5.0"
15
16 MARKER_REQUEST_HANDLER_TYPE="STANDARD"
17 STANDARD_MARKER_REQUEST_HANDLER_DISCARD_PROB="0.5"
18 STANDARD_MARKER_REQUEST_HANDLER_SEED="1"
19
20 TYPE_CHANGE_REQUEST_HANDLER_TYPE="NONE"
21 # no additional variables needed
22
23 POSITION_REQUEST_HANDLER_TYPE="VECTOR"
24 VECTOR_POSITION_REQUEST_HANDLER_DISCARD_PROB="0.1"
25 VECTOR_POSITION_REQUEST_HANDLER_SEED="3"
26 VECTOR_POSITION_REQUEST_HANDLER_MODIFIER="(VECTOR_TRIMMER,1.5);(
    VECTOR_RANDOMIZER,5,2.5)"
27
28 VELOCITY_REQUEST_HANDLER_TYPE="VECTOR"
29 VECTOR_VELOCITY_REQUEST_HANDLER_DISCARD_PROB="0.1"
30 VECTOR_VELOCITY_REQUEST_HANDLER_SEED="3"
31 VECTOR_VELOCITY_REQUEST_HANDLER_MODIFIER="(VECTOR_TRIMMER,1.5);(
    VECTOR_RANDOMIZER,5,2.5)"

```

B.2 Robot file

The robotfile uses a csv-compatible format. Therefore the information for one robot has to be saved in exactly one line of the file. Each line contains the following data. The order of this data is important!

- ID-number
- initial position (x, y, z)
- initial type (for instance master, slave,...)
- initial velocity (x, y, z)
- initial acceleration (x, y, z)
- initial status (maybe sleeping or ready; still has to be specified more precisely)
- initial marker information (still has to be specified)
- algorithm to use (shortcut for an algorithm; still needs to be specified)

- color (using this color a robot is marked for instance for a special treatment during the visualization; this color isn't used anywhere else)
- coordinate system axes (triple $x_1, x_2, x_3, y_1, y_2, y_3, z_1, z_2, z_3$; this field will be left empty, if axes are supposed to be generated uniformly at random)

The first line always is (column headers):

```
1 "ID","x-position","y-position","z-position","type","x-velocity","y-velocity","
  z-velocity","x-acceleration","y-acceleration","z-acceleration","status","
  marker-info","algorithm","color","x-axis-1","x-axis-2","x-axis-3","y-axis-1",
  "y-axis-2","y-axis-3","z-axis-1","z-axis-2","z-axis-3"
```

Each non-number is quoted.

B.2.1 Example of a robot file

```
1 "ID","x-position","y-position","z-position","type","x-velocity","y-velocity","
  z-velocity","x-acceleration","y-acceleration","z-acceleration","status","
  marker-info","algorithm","color","x-axis-1","x-axis-2","x-axis-3","y-axis-1",
  "y-axis-2","y-axis-3","z-axis-1","z-axis-2","z-axis-3"
2 0,5.3,9.2,6.4,"master",1.5,2.5,3.5,1.5,2.5,3.5,"sleeping",0,"MASTER_ALGO"
  ,0,1,0,0,0,1,0,0,0,1
3 1,2.5,4.2,8.8,"slave",1.5,2.5,3.5,1.5,2.5,3.5,"ready",0,"SLAVE_ALGO"
  ,0,1,0,0,0,1,0,0,0,1
```

TODO type really "master"/"slave" or rather 0/1? (scenario_generator generates latter atm)



B.3 Obstacle file

Like the robot file the obstacle file uses a csv-compatible format. Therefore the information for one robot has to be saved in exactly one line of the file. Each line contains the following data. The order of this data is important!

- type (marker, sphere or box)
- position (x, y, z)
- marker information (still needs to be specified)
- $x/y/z$ -lengths or radius (depending on type)

The first line always is (column headers):

```
1 "type","x-position","y-position","z-position","marker-info","size-info","",""
```

Each non-number is quoted.

B.3.1 Example of an obstacle file

```
1 "type","x-position","y-position","z-position","marker-info","size-info","", ""  
2 "box",2.0,3.0,4.0,0,1.0,2.0,3.0,  
3 "sphere",3.4,5.2,5.1,0,5.0,"", ""  
4 "marker",3.5,1.4,5.1,0,"", "", ""
```

As you can already see in the example, if the type of an obstacle is sphere, then the last two values must be empty, i.e. ", ". Analogously, if the type is marker, the last three values must be empty, i.e. ", ", "".

