Multi-agent model manual

目次

1 System configuration

The system configuration of the multi-agent model is shown in Figure 1-1. The multi-agent model receives 2-D depth and velocity data from CADMAS-SURF via communication or file, and uses this data to perform the simulation.

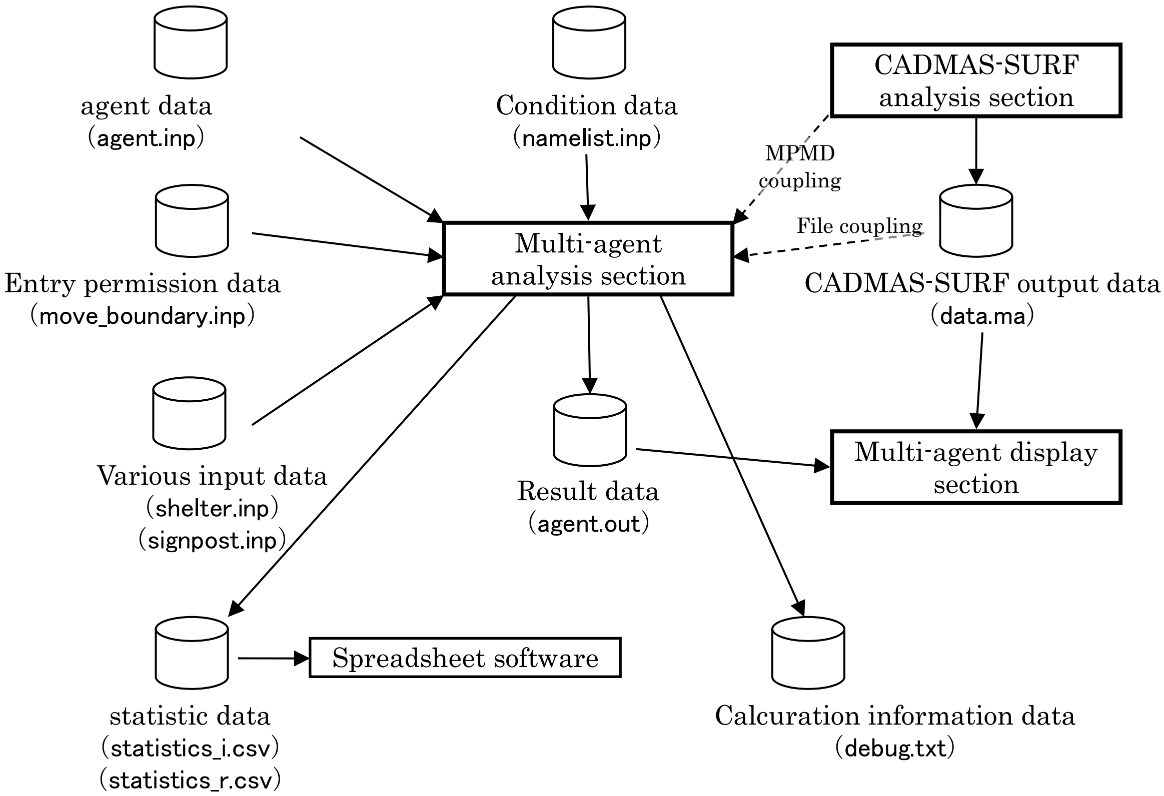

Figure 1-1 system configuration

2 Restrictions

2.1 Time step

In the multi-agent model, a 2-D mesh is used to determine the direction of agent movement. Therefore, although the movement of each agent itself is done in continuous coordinates rather than cell-by-cell, the movement per step is constrained by the mesh size. Specifically, the following equation (2 1) must be satisfied.

$$\Delta t \leq \frac{dx}{v_{\max}} \tag{2-1}$$

Δt :time step, dx :cell size, $v_{\max}$:maximum movement speed of the agent

3 Input/Output data

Table 3-1 below lists the input/output files for multi-agent analysis.

Table 3-1 Input/Output files

filename	I/O	format	Unit number	contents
namelist.inp	Input	ASCII	11	Condition data
agent.inp	Input	ASCII	12	Agete data
shelter.inp	Input	ASCII	22	Shelter data
signpost.inp	Input	ASCII	21	Signpost data
move_boundary.inp	JInput	ASCII	20	Entry permission data
Specify directory in namelist 0-fill 3-digit ex：000.txt	Input	ASCII		Shelter potential data (required when flag_WP=0)
Specify path in namelist ex:danger.inp	Input	ASCII		tsuanmi arrived time data (required when flag_danger=1)
Specify directory in namelist 0-fill 4-digit ex：0000.txt	Input	ASCII		Time-series tsunami arrived probability (required whenflag_prob=1)
data.ma	Input	BINARY	13	CADMAS-SURF output data
agent.out	Output	BINARY	14	Result data
statistics_i.csv	Output	ASCII	15	Integer type statstics data
statistics_r.csv	Output	ASCII	16	Real type statistics data
debug.txt	Output	ASCII	100	Calcuration information data

3.1 Input data

3.1.1 Condition data（namelist.inp）

Specify the basic analysis conditions. A sample of analysis condition data is shown in Figure 3-1.

```
&time
  maxstep = 9999    ! maximum step
  start   = 0.0d0   ! analysis start time[s]
  end     = 200.0d0 ! analysis end time[s]
  dt      = 0.1d0   ! time interval[s]
/
&agent
  n_rw = 1        ! 1:consider RandomWalk 0:not consider
  rw_dt = 2.0d0   ! update interval of randomwalk information (rw_theta)[s]
  n_slope = 1     ! 1:consider slope_function 0:not consider
/
&potential
  xpin  = 0.0d0   ! x-directional origin point coordinates of potential grid [m].
  ypin  = 1.0d0   ! y-directional origin coordinates of potential lattice [m].
  ipmax = 60      ! number of i-directional divisions of potential grid
  jpmax = 40      ! number of j-directional divisions of potential grid
  dxy  =  5.0d0   ! cell size of potential grid[m]
  n_signpost = 2  ! >1:number of signposts   0:not consider
  n_shelter = 2   ! >1:number of shelters  0:not consider
  n_mob = 0       ! 1: Consideration of crowd psychology 0:not consider
  r_mob =50.0d0   ! range of crowd counts[m]
/
&output
  out_start    = 0.0d0   ! output start time[s]
  out_end      = 200.0d0 ! output end time[s]
  out_interval = 2.0d0   ! output interval[s]
/
&offline
  nregion = 1             ! number of ma files
  file = "../data.ma"     ! ma file path
/
&flag
  flag_WP       = 0    ! potential write OnOff flag for shelter 1:write 0:not write
  flag_RP       = 0    ! potential read OnOff flag for shelter 1:wriet 0:not read
  flag_danger   = 0    ! avoiding tsunami route sarching method OnOff flag 1:consider 0:not cosider
  flag_prob     = 0    ! searching low tsunami probability route method OnOff flag 1:consider 0:not consider
/
&danger                          ! require when flag_danger=1
  danger_path = "../danger.txt"  ! tusnami arrived time data path
/
&prob                              ! required when flag_prob=1
  ini_prob               = 1       ! initial probability of avoidance
  relaxation_rate        = 1       ! increased probability of avoidance
  tsunami_prob_directory = "prob/" ! directory of tsunami probability files
  flag_WPprob            = 1       ! OnOff flag writing potential for each indivisual 1:write 0:not write
  flag_RPprob            = 1       ! OnOff flag reading potential for each indivisual 1:read 0:not read
  n_pot_directory        =  "np/"  ! directory of lpotential for indivisual
```

figure 3-1　condition data（namelist.inp）

3.1.2　Agent data（agent.inp）

The attributes specific to each agent are set in agent.inp. Lines with "#" at the beginning are skipped. The items are comma-separated from left to right: Index, initial x-coordinate [m], initial y-coordinate [m], movement speed [m/s], water level to determine mortality [m], standard deviation of directional uncertainty [deg], probability of following signposts (0.0 to 1.0), weight coefficient for evacuation route potential (0.0 or more), weight coefficient for crowd potential (0.0 or more), weight coefficient for evacuation route potential (0.0 or more), weight coefficients (greater than or equal to 0.0), and evacuation start time(0.0 or more). A sample of the agent data is shown in Figure 3-2.

```
#N,  X0, Y0, Velcity, Deadline, rw_sigma, W_signpost,  W_shelter, W_mob, agent_start
 1,   70, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 2,   90, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 3,  110, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 4,  130, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 5,  150, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 6,  170, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 7,  190, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 8,  210, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
 9,  230, 150, 3.0,    1.0,      30.0,     0.5,        1.0,       0.1,           0.0
```

Figure 3-2　agent data（agent.inp）

3.1.3　Shelter data（shelter.inp）

If n_shelter is set to 1 or more in the namelist.inp, shelter.inp is required as shelter data. Lines with "#" at the beginning are skipped. The items to be specified are, from left to right, Index, cell number in x-direction, cell number in y-direction, and shelter height (height from the ground), separated by commas. A sample of shelter data is shown in Figure 3-3.

```
#N,  i,  j,  z
 1,  1, 40, 20
 2, 60, 40, 30
```

Figure 3-3　Shelter data（shelter.inp）

3.1.4 Signpost data（signpost.inp）

If n_signpost is set to 1 or more in the namelist.inp, signpost.inp is required as signpost data. Lines with "#" as the first character are skipped. The items to be specified are, in order from left to right, Index, cell number in x direction, cell number in y direction, effective radius of signpost [m], and direction of signpost [deg.] (x direction is 0.0 [deg.] and counterclockwise is positive). A sample of the wayfinding data is shown in Figure 3-4.

```
#N,  i,  j,  r, theta
 1, 26, 40, 50,     0
 2, 35, 40, 50,     0
```

Figure 3-4　Sinpost data（signpost.inp）

3.1.5 Entry permission data（move_boundary.inp）

The agent's entry to adjacent cells is set in move_boundary.inp. The cell that can be entered is set to 0, and the cell that cannot be entered is set to -1. A sample of move_boundary.inp data is shown in Figure 3-5.

```
#
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 0 0 0 0 0 0 0 0 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 0 0 0 0 0 0 0 0 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

Figure 3-5　Entry permission data（move_boundary.inp）

3.1.6 Shelter potential data（requred when flag_WP=0）

Data to read the potential fields for each shelter, written out with Flag_WP=1.

The number is a 0-filled 3-digit number similar to the order of shelter.inp. The directory is specified in namelist.inp.

A sample of time series tsunami arrival probability is shown in Figure 3-6。

```
9999.00  166.79   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  167.80   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  168.81   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  169.80   170.19   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  170.80   171.20   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  171.61   171.19   9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  170.18   9999.00  9999.00  9999.00  9999.00  9999.00
9999.00   9999.00 9999.00  169.14   168.75   9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  167.72   9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  166.70   166.25   9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  9999.00  165.27   9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  9999.00  164.35   163.91   9999.00  9999.00
156.08   157.08   9999.00  9999.00  9999.00  9999.00  163.07   9999.00  9999.00
9999.00  157.53   158.58   159.64   160.70   161.75   162.75   163.71   9999.00
```

Figure 3-6　Shelter potential data（例：001.txt）

3.1.7 Tsunami arrival time data（required when flag_danger=1）

Data describing the tsunami arrival time (in seconds), specified as a path in namelist.inp. A sample tsunami arrival time is shown in Figure 3-7.。

```
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    679.20
0.00    0.00    0.00    0.00    0.00    0.00    682.80  678.95
0.00    0.00    0.00    0.00    0.00    691.80  683.55  675.31
0.00    0.00    0.00    0.00    0.00    691.20  682.95  674.49
0.00    0.00    0.00    0.00    829.48  715.48  677.19  671.28
0.00    0.00    0.00    0.00    689.19  680.73  673.41  667.37
0.00    0.00    0.00    0.00    685.23  677.43  669.57  663.53
0.00    0.00    0.00    0.00    683.11  674.19  665.98  659.90
0.00    0.00    0.00    0.00    678.21  670.01  662.36  656.32
0.00    0.00    0.00    0.00    671.89  665.19  658.06  652.21
726.60  714.00  705.00  678.60  664.46  658.53  653.57  647.66
```

Figure 3-7　Tsunami arrival time data（ex : danger.txt）

3.1.8 Time-series tsunami arrived probability data（required when flag_prob）

Data describing the probability of tsunami arrival in a time series. Probability is between 0 and 1. A file with 0-filled 4-digit names for each second. The directory is specified by namelist.inp. A sample time-series tsunami probability is shown in Figure 3-8.

```
25.00  25.00  25.00  25.00  25.00  25.00  25.00  25.00  28.00
25.00  25.00  25.00  25.00  25.00  25.00  25.00  28.00  28.00
25.00  25.00  28.00  28.00  28.00  28.00  28.00  29.00  30.00
25.00  27.00  28.00  28.00  28.00  29.00  29.00  30.00  30.00
25.00  28.00  29.00  29.00  29.00  30.00  30.00  30.00  30.00
27.00  29.00  30.00  30.00  30.00  30.00  30.00  30.00  30.00
28.00  29.00  30.00  30.00  30.00  30.00  30.00  0.00   0.00
28.00  29.00  32.00  45.00  45.00  0.00   0.00   0.00   0.00
28.00  28.00  39.00  56.00  56.00  0.00   0.00   0.00   0.00
32.00  32.00  17.00  0.00   0.00   0.00   0.00   0.00   0.00
33.00  33.00  18.00  0.00   0.00   0.00   0.00   0.00   0.00
52.00  70.00  70.00  0.00   0.00   0.00   0.00   0.00   0.00
57.00  70.00  70.00  0.00   0.00   0.00   0.00   0.00   0.00
57.00  68.00  68.00  0.00   0.00   0.00   0.00   0.00   0.00
55.00  65.00  65.00  0.00   0.00   0.00   0.00   0.00   0.00
52.00  63.00  68.00  68.00  0.00   0.00   0.00   0.00   0.00
```

Figure 3-8　Time-series tsunami arrived probability data（ex : 0920.txt）

3.1.9 Evacuee potential data（required when Flag_RPprob=1）

Data describing the potential place for each evacuee, written out with Flag_WP=1.

The number is a 0-filled 4-digit number similar to the order of agent.inp. The directory where the files are located is specified in namelist.inp. A sample of potential data per evacuee is shown in Figure 3-9.

```
9999.00  166.79   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  167.80   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  168.81   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  169.80   170.19   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  170.80   171.20   9999.00  9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  171.61   171.19   9999.00  9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  170.18   9999.00  9999.00  9999.00  9999.00  9999.00
9999.00   9999.00 9999.00  169.14   168.75   9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  167.72   9999.00  9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  166.70   166.25   9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  9999.00  165.27   9999.00  9999.00  9999.00
9999.00  9999.00  9999.00  9999.00  9999.00  164.35   163.91   9999.00  9999.00
156.08   157.08   9999.00  9999.00  9999.00  9999.00  163.07   9999.00  9999.00
9999.00  157.53   158.58   159.64   160.70   161.75   162.75   163.71   9999.00
```

Figure 3-9　Evacuee potential data（例 : 0001.txt）

3.1.10 CADMAS-SURF output data（data.ma）

CADMAS/SURF input file (data.in) with input in the format illustrated in Figure

3-10, which is output during CADMAS/SURF analysis. data.ma is used when computing the multi-agent model stand-alone (offline) and during visualization. data.ma is used for the BINARY (FORTRAN unformatted) format. The output format is shown in Table 3-2.

```
OBST 28 26  1 28 30 31
OBST 29 26  1 29 30 32
OBST 30 26  1 30 30 33

B.C.   D                    VP  SLIP
B.C.   D                    F   FREE
B.C.   Z  1  1  1 30  5  1  VP  FIX-V  0.00  0.00  1.00

FILE GRP TIME       0.0 9999.9  1.0
FILE MAM TIME       0.0 9999.9  1.0

FILE L/P TIME       0.0 9999.9  1.0
FILE L/P AREA YZ     15      15
FILE L/P OFF  OBST
FILE L/P OFF  BC-IND
```

Add this part

Figure 3-10 part of CADMAS-SURF input data (data.in)

Table 3-2 CADMAS-SURF outut data (data.ma)

① Header section (output only once at the beginning)		
record1	icmax	jcmax
	number of x cells in CADMAS mesh integer	*number of x cells in CADMAS mesh integer*
record2	(xc(i),i=0,icmax)	
	CADMAS mesh division position in x direction real(8)	
record3	(yc(j),j=0,jcmax)	
	CADMAS mesh division position in y direction real(8)	
record4	((height_c(i,j),i=1,icmax),j=1,jcmax)	
	Elevation data real(4)	
② Main unit (output repeated at each specified time)		
record1	cadmas_tnext	
	Time real(4)	
record2	((depth_c(i,j),i=1,icmax),j=1,jcmax)	
	Depth of water real(4)	
record3	((uu_c(i,j),i=1,icmax),j=1,jcmax)	
	Velocity in x direction real(4)	
record4	((vv_c(i,j),i=1,icmax),j=1,jcmax)	
	Velocity in y direction real(4)	

3.2 Output data

3.2.1 Result data（agent.out）

The full of multi-agent analysis result data is written out to agent.out, in BINARY(fortran's unformatted) format. The output format is shown in Table 3-3.

Table 3-3 Result data（agent.out）

①Header section (output only once at the beginning)		
record1	N_agent	
	Number of agent	
(続 record1)	N_I_statistics	N_R_statistics
	Number of integer statistics to output	*Number of real statistics to output*
(続 record1)	N_I_attribute_F	N_R_attribute_F
	Fiexed number of attributes of integer type	*Fixed number of attributes of integer type*
(続 record1)	N_I_attribute_FV	N_R_attribute_V
	Variable attribute integer of integer type	*Variable attribute integer of real type*
record2	(String_I_statistics(I),I=1,N_I_statistics)	
	Explanation char(32) of statistics of integer type	
record3	(String_R_statistics(I),I=1,N_R_statistics)	
	Explanation char(32) of statistics of real type	
record4	(String_I_attribute_F(I),I=1,N_I_attribute_F)	
	Integer type fixed attribute description char(32)	
record5	(String_R_attribute_F(I),I=1,N_R_attribute_F)	
	Real type fixed attribute description char(32)	
record6	(String_I_attribute_V(I),I=1,N_I_attribute_V)	
	Variable attribute description char(32) of integer type	
record7	(String_R_attribute_V(I),I=1,N_R_attribute_V)	
	Variable attribute description char(32) of real type	
record8	(I_attiribute_F(I),I=1,N_I_attribute_F)	
	Fixed attribute value of integer type integer	*Repeat records 8 and 9 N_agent times*
record9	(R_attiribute_F(I),I=1,N_R_attribute_F)	
	Fixed attribute value of real type real(4)	
③ Main unit (output repeated at each specified time)		
record1	time	nstep
	Time real(8)	*Step integer*
record2	(I_statistics(I),I=1,N_I_statistics)	
	Value of integer type statistic integer	
record3	(R_statistics(I),I=1,N_R_statistics)	
	Value of real type statistic real(4)	
record4	(I_attiribute_V(I),I=1,N_I_attribute_V)	
	Variable attribute value of integer type integer	*Repeat records 4 and 5 N_agent times*
record5	(R_attiribute_V(I),I=1,N_R_attribute_V)	
	Variable attribute value real of real type real(4)	

3.2.2 Statistics data（statistics_i.csv, statistics_r.csv）

Integer type statistics data are output to statistics_i.csv and real type statistics are output to statistics_r.csv at each output time. For time series graphing. in ASCII (CSV) format. A sample is shown in Figure 3-11.

#time	Number of escaped	Number of moving	Number of dead
0	0	9	0
2	0	9	0
4	0	9	0
6	0	9	0
8	0	9	0
10	0	9	0
12	0	9	0
14	0	9	0
16	0	9	0
18	0	9	0
20	0	9	0
22	0	9	0
24	0	9	0
26	0	8	1
28	0	8	1
30	0	7	2
32	0	7	2
34	0	7	2
36	0	7	2
38	0	7	2
40	0	7	2
42	0	7	2
44	0	7	2
46	0	7	2
48	0	7	2
50	0	6	3
52	0	6	3
54	0	6	3
56	0	6	3
58	0	6	3
60	0	6	3
:	:	:	:

Figure 3-11　Statistics data（statistics_i.csv）

4 Executing tool

4.1 Example of executing a coupled calculation with CADMAS/SURF

① Prepare a set of input files required for CADMAS/SURF and multi-agent calculations in the calculation execution directory

```
/calc_MPMD % ls
agent.inp   data.in             namelist.inp   signpost.inp
data.env    move_boundary.inp   shelter.inp
```

② Prepare an appfile file to specify the calculator to be used

```
/calc_MPMD % cat appfile
machine1 0 %CD%/CADMAS  ← Running tsunami calculations with machine1
machine2 1 %CD%/MA      ← Running a Multi-agent calculation with machine2
```

③ Prepare a go script to perform the calculation

```
/calc_MPMD % cat go
#!/bin/bash

# Definition
CD=`pwd`
CADMAS=../src_cad/a.3d-mg10-opt  ← Load modules for CADMAS-SURF
MA=../src_ma/ma.out  ← Load modules for Multi-agent

# Remove
/bin/rm data.list* data.grp* data.tran* list.out agent.out *¥.csv
/bin/rm appfile1                                        > /dev/null
2>&1
sed -e "s@%CD%@$CD@" appfile > appfile1

# Clean & Exit
if [ "$1" == "clean" ]; then
  exit
fi

# Setting
if [ -f $CADMAS ]; then /bin/cp -fp $CADMAS CADMAS; fi
if [ -f $MA     ]; then /bin/cp -fp $MA     MA    ; fi

mpirun -p4pg appfile1 $CD/CADMAS

exit
```

④ Execute

```
/calc_MPMD % ./go
```

4.2 Example of performing a single (offline) calculation

① CADMAS/SURF calculations are performed in advance to obtain data.ma for multi-agent analysis

```
/calc_CADMAS-SURF % ls
data.env  data.in
/calc_CADMAS-SURF % mpirun -np 1 ../src_cad/a.3d-mg10-opt
```

Load module of CADMAS-SURF

② Prepare a set of input files (including data.ma obtained in (1) above) necessary for multi-agent calculation in the calculation execution directory.

```
/calc_FILE % ls
agent.inp  move_boundary.inp  shelter.inp
data.ma    namelist.inp       signpost.inp
```

③ Execute Multi-agent calculation

```
/calc_FILE % mpirun -np 1 ../src_ma/ma.out
```

Load module of Multi-agent

5　Viualizatin tool (CADMAS VR)

5.1　Reading input data

The input files required are the .grp file output from CADMAS-SURF and the multi-agent analysis result data agent.out. Start the visualization tool and select the agent.out file and the .grp file as shown in Figure 5-1.

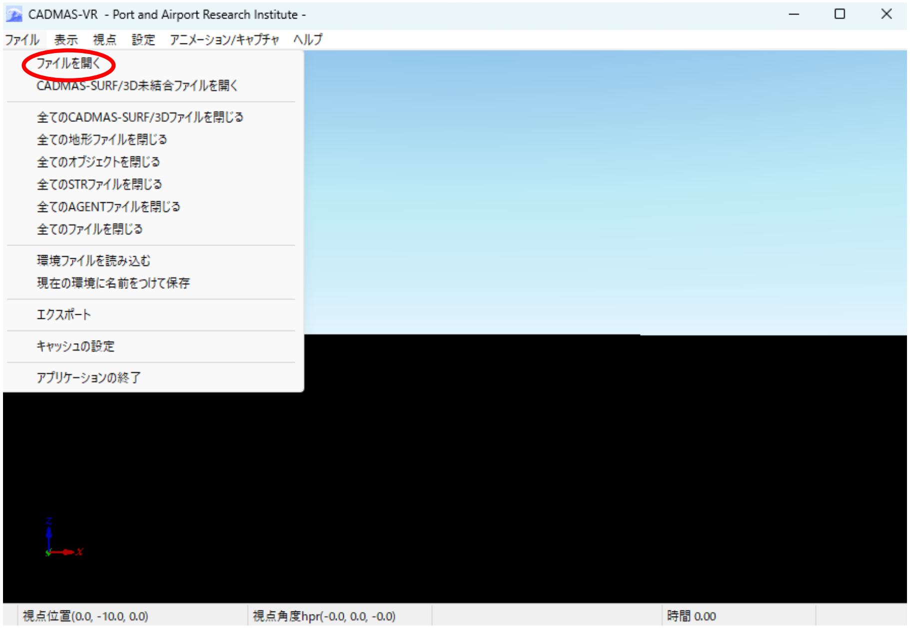

Figure 5-1　Startup view

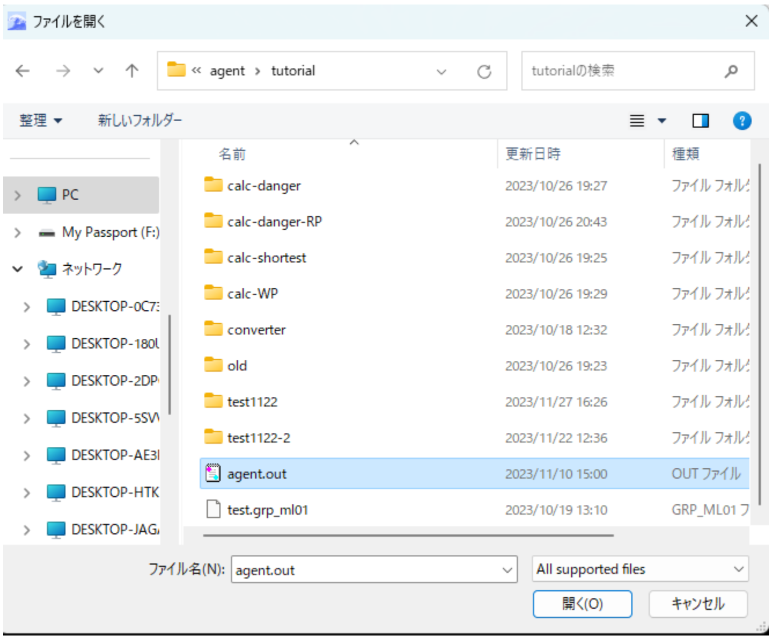

Figure 5-2　File selection view

5.2 Operation procedures

The following is a description of the operation screen after input data has been loaded. From the layer selection window, select the file to be operated on and press the "Fit" button to move the starting point to the file display area (①). The viewpoint angle can be changed by scrolling with the left mouse button, zooming in/out with the right mouse button, and scrolling while holding down the mouse wheel. From the settings, .grp files and agent.out files can be set (②). In addition, by displaying and operating the animation capture, it is possible to play and stop the animation. Figure 5 3 shows how the above operations are performed.

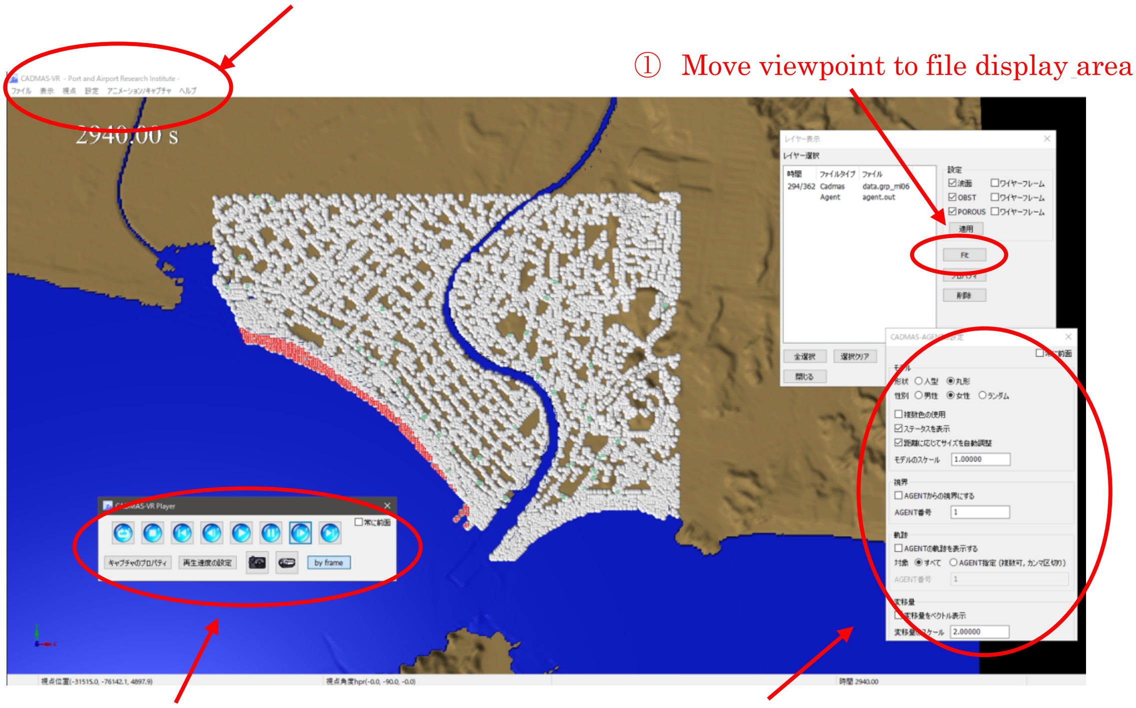

Figure 5-1 File visualization settings

6 Program description

6.1 Module

The modules defined in the multi-agent model are listed in Table 6-1. In addition, module variables are shown in 6.1.1 through 6.1.5 below.

Table 6-1 Modules list

Module name	discription	Contained subroutine
m_agent	modules about agents	allocate_agent
m_cadmas	Modules about CADMAS-SURF	allocate_cadmas_c
m_potential	modules about potential	allocate_move_boundary allocate_pot_mob allocate_pot_shelter allocate_signpost allocate_n_potential allocate_m_pot_shtelte
m_timectl	modules about time integration	
m_output	modules about ouptut	
m_flag	modules about evacuation route search method flag	
m_danger	modules about tsunami inundation avoiding route searching method	
m_prob	modules about low tsunami arrived probabilities route searching method	

6.1.1 module variables about agents（m_agent）

Table 6-2 shows the module variables about agent.

Table 6-2 Modules variables about agents

variable name	type	dimension	description
n_agent	I		Number of agents
i_agent	I	(n_agent)	Agent's cell position in x direction
j_agent	I	(n_agent)	Agent's cell position in y direction
agent_x	R	(n_agent)	Agent x-coordinate
agent_y	R	(n_agent)	Agent y-coordinate
agent_u	R	(n_agent)	Movement speed of agent in x direction
agent_v	R	(n_agent)	Movement speed of agent in y direction
vel	R	(n_agent)	Movement speed of agent
agent_status	I	(n_agent)	Agent status (0: evacuated, 1: moving, 2: moving (underwater), 3: dead)
istat_escaped	I		Number of escaped agents
istat_moving	I		Number of moving agents
istat_dead	I		Number of dead agents
deadline	R	(n_agent)	Depth of water the agent can tolerate (above this depth, the agent dies)
n_rw	I		Flag whether to consider directional uncertainty
rw_dt	I		Progressive uncertainty (rw_theta) update interval
rw_tnext	R		Next time to update rw_theta
rw_sigma	R	(n_agent)	Standard deviation of angle difference between target direction and direction of travel by RandomWalk
rw_theta	R	(n_agent)	Angular difference between target direction and direction of travel by RandomWalk (updated every rw_dt))
weight_signpost	R	(n_agent)	Probability of following the agent's signposts
iflag_signpost	I	(n_agent,n_signpost)	Whether or not each agent follows the signposts
weight_shelter	R	(n_agent)	Weights on the agent's evacuation route potential
weight_mob	R	(n_agent)	Weights on the agent's crowd psychology potential
Agent_start	R	(n_agent)	Agent evacuation start time

6.1.2 module variables about CADMAS-SURF（m_cadmas）

Table 6-3 shows the module variables about CADMAS-SURF defined in m_cadmas。

Table 6-3 Module variables about CADMAS-SURF

variable name	type	dimension	description
icmax	I		Number of x-directional divisions of topographic mesh in CADMAS-SURF output
jcmax	I		Number of y-directional divisions of the topographic mesh in the CADMAS-SURF output
xc	R	(0:icmax)	Divisions of topographic mesh in x-direction for CADMAS-SURF output
yc	R	(0:jcmax)	Split positions of topographic mesh in y-direction for CADMAS-SURF output
cadmas_tnow	R		Time of CADMAS-SURF output data
cadmas_tnext	R		Next update time of CADMAS-SURF output data
cadmas_rank	I		PE number of CADMAS-SURF (-1 when not coupled)
height_c	R	(icmax,jcmax)	Topographic height (CADMAS-SURF output data)
depth_c	R	(icmax,jcmax)	Bathymetry depth (CADMAS-SURF output data)
uu_c	R	(icmax,jcmax)	Current velocity u(CADMAS-SURF output data)
vv_c	R	(icmax,jcmax)	Current velocity v(CADMAS-SURF output data)
height	R	(ipmax,jpmax)	Topographic height (Equal interval mesh data for multi-agent)
depth	R	(ipmax,jpmax)	Bathymetry depth (Equispaced mesh data for multi-agent)
uu	R	(ipmax,jpmax)	Current velocity u (Equispaced mesh data for multi-agent)
vv	R	(ipmax,jpmax)	Current velocity v (Equispaced mesh data for multi-agent)

6.1.3 Module variables about potential（m_potential）

Table 6-4 shows the modules about potential variables defined in m_potential

Table 6-4 Module variables about potential

variable name	type	dimension	description
xpin	R		Base point x-coordinate of potential lattice [m]
ypin	R		y-coordinate of the base point of the potential mesh [m]
ipmax	I		Number of x-directional divisions of potential mesh
jpmax	I		Number of divisions in y direction of potential mesh
dxy	R		Lattice spacing of potential mesh [m].
move_boundary	I	(ipmax,jpmax)	Array specifying whether or not to enter adjacent cells
n_signpost	I		Number of road signs (and OnOff flag)
i_signpost	I	(n_signpost)	Location of shelters
j_signpost	I	(n_signpost)	Refuge location
r_signpost	R	(n_signpost)	Effective radius of road markers [m].
theta_signpost	R	(n_signpost)	Direction of each road sign
narea_signpost	I	(ipmax,jpmax)	Effective range of each road sign within the area
n_shelter	I		Number of shelters (and OnOff flag)
i_shelter	I	(n_shelter)	x-position of the shelter cell
j_shelter	I	(n_shelter)	y-position of the shelter cell
pot_shelter	R	(ipmax,jpmax)	Evacuation route potential array
m_pot_shlter	R	(ipmax,jpmax)	Array of potentials for each shelter
n_potential	R	(ipmax,jpmax)	Evacuee potentials per evacuee array
n_mob	I		Crowd potential OnOff flag
r_mob	R		Agent count range radius [m]
nsum_agent	I	(ipmax,jpmax)	Number of agents in cell array
pot_mob	R	(ipmax,jpmax)	Crowd potential array
pot_mob_revise	R	(ipmax,jpmax)	Crowd potential array (removing influence of agents themselves)

6.1.4 modules variables about time integration（m_timectl）

Table 6-5 shows the modules varibles about time integration defined in m_timectl.

Table 6-5　Modules about time integration 変数

variable name	type	dimension	description
nstep	I		Current number of calculation steps
maxstep	I		Maximum number of steps
time	R		Current time (s)
dt	R		Time increment(s)
time_start	R		Calculation start time(s)
time_end	R		Calculation end time(s)

6.1.5 Module variables about output（m_output）

Table 6 6 shows the module variables about the outputs defined in m_output.

Table 6-6　Module variables about output

variable name	type	dimension	description
out_start	R		Output start time (s)
out_end	R		End time of output (s)
out_interval	R		Output interval (s)
out_time	R		Next output time (s)
N_I_statistics	I		Number of series of statistics (integer type)
N_R_statistics	I		Number of series of statistical values (real type)
N_I_attribute_F	I		Number of series of fixed attribute values (integer type)
N_R_attribute_F	I		Number of series of fixed attribute values (real type)
N_I_attribute_V	I		Number of series of variable attribute values (integer type)
N_R_attribute_V	I		Number of series of variable attribute values (real type)
String_I_statistics	C	(N_I_statistics)	Label of statistical value (integer type)
String_R_statistics	C	(N_R_statistics)	Label of statistical value (real type)
String_I_attribute_F	C	(N_I_attribute_F)	Fixed attribute value (integer) labels
String_R_attribute_F	C	(N_R_attribute_F)	Fixed attribute value (real type) labels
String_I_attribute_V	C	(N_I_attribute_V)	Variable Attribute Value (Integer) Labels
String_R_attribute_V	C	(N_R_attribute_V)	Variable attribute value (real type) labels
I_statistics	I	(N_I_statistics)	Statistics (integer type)
R_statistics	R	(N_R_statistics)	Statistics (Real)
I_attribute_F	I	(N_I_attribute_F)	Fixed Attribute Value (Integer)
R_attribute_F	R	(N_R_attribute_F)	Fixed Attribute Value (Real)
I_attribute_V	I	(N_I_attribute_V)	Variable Attribute Value (Integer)
R_attribute_V	R	(N_R_attribute_V)	Variable Attribute Value (Real)

6.1.6　Module variables about evaruation search method flag（m_flag）

Table 6-6 shows module variables about evacuation search method flag defined in m_flag.

Figure 6-7　Module variables about evacuatin search method flag

variable name	type	dimension	description
flag_WP	I		ポテンシャル書き出し OnOff フラグ
Flag_RP	I		ポテンシャル読み込み OnOff フラグ
flag_danger	I		津波浸水回避経路探索(=1)
flag_prob	I		津波浸水確率考慮経路探索(=1)

6.1.7　Module variables about tsunami inundation avoiding route searching method （m_danger）

Table 6-6 shows module variables about tsunami inundation aboiding route searching method defined in m_danger.

Table 6-8　Module variables about tsunami inundation avoiding route searching method

variable name	type	dimension	description
danger_path	C		Path of tsunami arrival time files

6.1.8　Module varables about tsunami inundation avoiding route searching method （m_prob）

Table 6-6 shows module variables about tsunami inundation avoiding route searching method defined in m_output.

Table 6-9　Module variables about tsunami inudatio avoiding route searching method

variable name	type	dimension	description
ini_prob	R		Initial avoiding setting probability
relaxation_rate	R		Relaxation increments of avoidance setting probability
tsunami_prob_directory	C		Directory of time-series tsunami inundation probability distribution
n_pot_directory	C		Directory of per-evacuee potentials (when required flag_RP=1)
flag_WPprob	I		OnOff flag for writing evacuee potentials
flag_RPprob	I		OnOff flag for reading evacuee potentials

6.2 Subroutine description and process flow

Table 6-7 shows subroutine list, and Figure 6-1 shows process flow

Table 6-7 Subroutine list

subroutine name	description
allocate_agent	Memory Allocation to Array for Agents
allocate_cadmas	Memory allocation to the array for remesh'd CADMAS data
allocate_cadmas_c	Memory allocation to array for CADMAS-SURF output data
allocate_move_boundary	Memory allocation to array for specifying whether or not to enter adjacent cells
allocate_pot_mob	Memory allocation to array for crowd potentials
allocate_pot_shelter	Memory allocation to arrays for evacuation route potentials
allocate_potential	Allocation of memory to arrays related to potentials to be used (related to determining direction of movement)
allocate_signpost	Memory allocation to array for road signs
errmsg	Output error message
errstop	Stop calculation
get_direction	Specify the movement direction of the agent
initialize	Initialization
main	Main routine
make_potential_mob	Update crowd potential
make_potential_mob_revise	Set crowd potential excluding the influence of the agent itself
make_potential_shelter	Set evacuation route potentials
make_n_potential	Set potentials for each evacuee (process varies depending on flag)
make_signpost	Set up signposts
move_agent	Calculate agent movement
open_un90	Open machine number 90 for log output (log_ma)
output	File output
pot_total	Add up the potentials to be considered with weights
random_normal	Generate regular random numbers
read_agent	Read agent file
read_cadmas	Read CADMAS-SURF output data
read_condition	Read in calculation conditions
read_move_boundary	Reading of input data to specify whether to move in or out
read_potential	Reading of potential-related (movement direction determination-related) input files
read_shelter	Reading in shelter data
read_signpost	Loading of signpost data
recursive_search_shelter	Recursive evacuation route distance search
remesh	Conversion of CADMAS-SURF output data to multi-agent mesh data
solver	Time integration calculation
update_attribute	Updating agent attributes
update_rw	Update RandomWalk information

main			
	read_condition		
	read_agent		
		allocate_agent	
	allocate_potential		
		allocate_move_boundary	
		allocate_distance_factor	
		allocate_signpost	
		allocate_pot_shelter	
		allocate_pot_mod	
		allocate_n_potential	
		allocate__m_pot_shelter	
	read_potential		
		read_move_boundary	
		read_distance_factor	
		read_signpost	
		read_shelter	
	read_cadmas		
		allocate_cadmas_c	
		allocate_cadms	
	solver		
		initialize	
		read_cadmas	
			remesh
		make_signpost	
		make_potential_shelter	
			recursive_serch_shelter
			make_n_potential
		update_attribute	
		output	
		nstep=1,maxstep	
		read_cadmas	
		update_rw	

		make_potential_mod	
		move_agent	
			get_direction
		update_attribute	
		output	
		end do	
		output	

Figure 6-1　Process flow

7 Introduced model

7.1 Poteintal model

Since a variety of factors may be involved in determining the agent's direction of movement, we defined each factor individually as a potential and introduced a model that uses the superposition of these potentials to determine the direction of movement.

$$U_k = a_{k,1}u_1 + a_{k,2}u_2 + \cdots + a_{k,n}u_n + \cdots \tag{7-1}$$

U_k : Superposition potentials for the agent k

u_n : potential n

$a_{k,n}$: Weights for the agent k with respect to the potential n

Each agent looks at the potentials in its surroundings and takes a path in the direction with the lowest potential. Since it is difficult to define potentials by functions, etc., we decided to create a potential map by stretching a mesh for multi-agent analysis over the analysis area, and each agent decides its path by looking at the potentials of the 8 meshes around it.

In addition, as a framework, it is also possible to define individual potentials for each agent and to define superimposed potentials as shown in (7-2) below.。

$$U_k = a_{k,1}u_{k,1} + a_{k,2}u_{k,2} + \cdots + a_{k,n}u_{k,n} + \cdots \tag{7-2}$$

$u_{k,n}$: potential n of the agent k

7.1.1 Shelter potential

For each cell in the mesh for the Multi-agent analysis, the shortest distance (not a straight line distance) to the nearest evacuation center was calculated and the inverse of that distance multiplied by -1 was used as the evacuation route potential. The potential for the shelter cell was set to -10^{10}, and the potential for the cell with no route to the shelter was set to -10^{-10}.

$$u_{shelter}(i, j) = -1 / r(i, j) \tag{7-3}$$

$u_{shelter}$: shelte potential

$r(i, j)$: Minimum distance from the (i , j) cell to the nearest shelter

7.1.2 Mob potential

For each cell in the mesh for multi-agent analysis, the degree of crowding around it was calculated and a crowding potential was set. When the potentials are actually used to determine the direction of each agent, the influence of the agent in question is subtracted from the potentials.

$$u_{mob}(i, j) = -\sum_{k=1} \frac{1}{d_k(i, j)} \qquad (d_k \leq r_{mob}) \tag{7-4}$$

u_{mob} : mob potential

$d_k(i, j)$: Distance from the kth agent to the (i , j) cell

r_{mob} : Range of crowd density calculation (name list input value)

7.2 Signpost model

We have introduced the effect of road signs. When an agent entered the effective range cell of a signpost, it takes a path in the direction indicated by the signpost according to the "probability of following the signpost" that each agent has. Agents that do not follow the signpost will continue to follow the path according to their potential.

7.3 Rando walk model

Introduced a model that provides uncertainty for the direction of movement determined by potentials and signposts, etc.

$$\theta = \theta_{pot} + \theta_{rw} \tag{7-5}$$

θ : Agent movement direction

θ_{pot} : Direction of movement determined by potentials and signposts

θ_{rw} : Random number following a normal distribution

(mean 0.0, standard deviation σ_{rw})

σ_{rw} : Movement direction uncertainty for each agent

7.4 Model of searching route avoiding tsunami inundation

A model of searching route avoiding tsunami inundation was introduced. The flow is shown in Figure 7-1（2. Sakata, Y., Suzuki, W., Arikawa T., Aoi, S.: Construction of decision support system for tsunami evacuation based on tsunami scenario bank, Journal of Japan Society of Civil Engineers, Ser. B2 (Coastal Engineering), Vol. 76, No. 2, pp. I_1249-I_1254, (2020). Figure 4）。

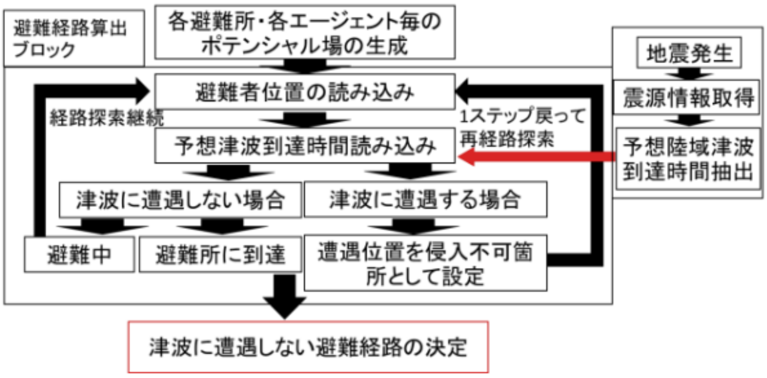

Figure 7-1 model flow of searching route avoiding tsunami inudnation

7.5 Model of serching route with low tsunami arrived probabirity

A model of searching route with low tsunami arrived probability was introduced. Figure 7-2 shows model flow（Ishiyama, I., Yoshida F., Shirai T., and Arikawa T. Evacua-tion route selection method using arriaval probability as ad-vance information. International Conference on Asian and Pacific Coasts, APAC2023, 2023. (in press) fig 1 ）

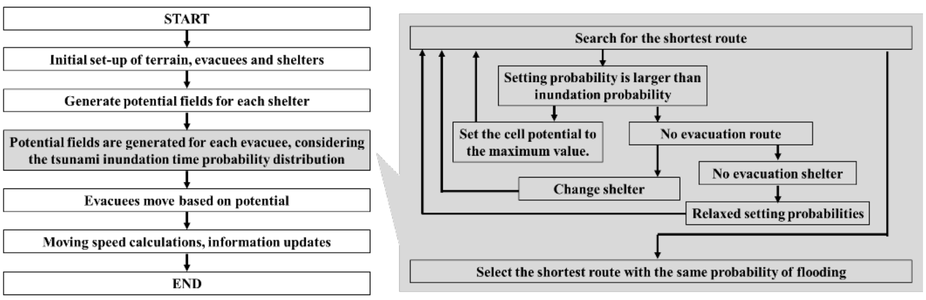

Figure 7-2 Model flow of searching route with low tsunami arrived probability