


References

- [1] S. R. Musse, and D. Thalman, "A Model of Human Crowd Behavior: Group Inter Relationship and Collision Detection Analysis", in Proceeding of Eurographics Workshop on Computer Animation and Simulations 97, 1997, pp. 39-51.
- [2] Foudil, C. and D. Nouredine (2007). "An Autonomous and Guided Crowd in Panic Situations" Journal of Computer Science & Technology 2(2): 134-140.
- [3] Helbing, D.; Farkas, I.; Molnar, P. and Vicsek, T., 2001. "Simulating of Pedestrian Crowds in Normal and Evacuation Situations. In M.Schreckenberg, S.D. Sharma(ed.) Pedestrian and Evacuation Dynamics. Springer Verlag Berlin and Heidelberg, pp. 21-58, 2001.
- [4] Helbing, D.; Farkas, I. and Vicsek, T., 2000. "Simulating Dynamical Features of Escape Panic". Nature, v. 407, pp. 487-490, 2000.
- [5] Richard Leggette, (2004). "Real Time Crowd Simulation: A Review"
 University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mug.ac.lk
- [6] Bruno S. Freya, David A. Savage, and Benno Torgler: "Interaction of natural survival instincts and internalized social norms exploring the Titanic and Lusitania disasters"
- [7] Mintz A (1951) "Non-adaptive group behavior". J Abnorm Psychol 46:150–159.
- [8] Kelley HH, Condry JC, Dahlke AE, Hill AH (1965) "Collective behavior in a simulated and panic situation". J Exp Soc Psychol 1:20–56.
- [9] Kincho H. Law, Ken Dauber and Xiaoshan Pan – "Computational Modeling of Nonadaptive Crowd Behaviors for Egress Analysis"
- [10] La Piere, R. (1938). "Collective Behavior". New York: McGraw-Hill.
- [11] Smelser, N. (1963). "Theory of Collective Behavior". New York: Free Press.
- [12] Mintz, A. (1951). "Non-Adaptive Group Behavior". Journal of Abnormal and Social Psychology, 29, 150-159.

- [13] Kelley, H., Condry, J., Dahlke, A, and Hill, A. (1965). "Collective Behavior in a simulated panic situation". *Journal of Experimental Social Psychology*, 1, 20-54.
- [14] Katsuhiro Nishinari, Ken Sugawara, Toshiya Kazama, Andreas Schadschneider and Debashish Chowdhury – "Modelling of self-driven particles": foraging ants and pedestrians
- [15] A.S. Mikhailova and V. Calenbuhr, "From Cells to Societies" (Springer, Berlin, 2002).
- [16] E. Altshuler, O. Ramos, Y. Nu´nˆez, J. Ferna´ndez, A. J. Batista-Leyva and C. Noda : "Symmetry breaking in Escaping Ants"
- [17] Katia P. Sycara: "Multi-agent Systems"
- [18] George Rzevski, Petr Skobelev: "Emergent Intelligence in Large Scale Multi-Agent Systems"
- [19] Suraj Pandey, Linlin Wu, Siddeswara Mayura Guru, Rajkumar Buyya: "A Particle Swarm Optimization-based Heuristic for Scheduling Workflow Applications in Cloud Computing Environments"
- [20] C. Reynolds. "Flocks, Herds, and Schools: A Distributed Behavioral Model". *Proc. SIGGRAPH'87, Computer Graphics*, v.21, n.4. July, 1987.
- [21] X. Tu and D. Terzopoulos. "Artificial Fishes: Physics, Locomotion, Perception, Behavior". *Proc. SIGGRAPH'94, Computer Graphics*, July, 1994.
- [22] J.H.Yin, S. Velastin and A. C. Davies. "Measurement of Crowd Density using Image Processing" VII European Signal Processing Conference, EUSIPCO-94, Edinburgh, UK, Sept. 1994
- [23] Java Agent DEvelopment (JADE) framework – an Open-Source platform for peer-to-peer Multi Agent-based Applications - <http://jade.tilab.com/> (Last Viewed on 29th Jan 2012)

- [24] Java Programming Language - <http://www.oracle.com/technetwork/java/javase/downloads/index.html> (Last Viewed on 20th June 2012)
- [25] Human Behaviour in Fires – A publication by “Department for Communities and Local Government”, UK
<http://www.communities.gov.uk/archived/publications/fire/humanbehaviour> (Last Viewed On 23rd June 2012)
- [26] Hiroaki Notake , Yuka Ikehata , Jun'ichi Yamaguchi and Takeyoshi Tanaka - “Fire Risk-Based Evacuation Safety Derived from Statistical Analysis by Type of Building”
- [27] MASSIVE – Simulating Life - <http://www.massivesoftware.com/> (Last Viewed on 30th June 2012)
- [28] Stuart Russell and Peter Norvig - “Artificial Intelligence: A Modern Approach”, copyright 1995 Prentice-Hall, Inc.
- [29] Ana Luisa Ballinas-Hernandez, Angelica Muñoz-Melendez and Alejandro Rangel-Huerta – “Multi-agent System Applied to the Modeling and Simulation of Pedestrian Traffic in Counterflow” - Journal of Artificial Societies and Social Simulation 14 (3) 2, 2011 - <http://jasss.soc.surrey.ac.uk/14/3/2.html> (Last Viewed on 30th June 2012)
- [30] Takeshi Kimura, Tomonori Sano, Kazuto Hayashida, Naohiro Takeichi, Yoshikazu Minegishi, Yoshiyuki Yoshida, and Hitoshi Watanabe – “Representing Crowds with a Multi-agent Model - Development of the SimTread™ pedestrian simulation system” - J. Architecture Planning AIJ, Vol. 74 No. 636, 371-377, Feb., 2009

Appendix A:

Crowd Simulator; Input and Output Examples

A.1 Input Scenario Configuration

Following is an example for an input scenario consisting of a single fire source, 3 people (whom 1 is a fire warden and other 2 are ordinary people) and 2 exit points.

```
<?xml version="1.0"?>
<simulator>
  <exit>
    <id>1</id>
    <location>
      <xloc>100</xloc>
      <yloc>350</yloc>
    </location>
  </exit>
  <exit>
    <id>2</id>
    <location>
      <xloc>450</xloc>
      <yloc>400</yloc>
    </location>
  </exit>
  <individual>
    <type>NORMAL_PERSON</type>
    <location>
      <xloc>300</xloc>
      <yloc>400</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
  </individual>
  <individual>
    <type>FIRE_WARDEN</type>
    <location>
      <xloc>250</xloc>
      <yloc>325</yloc>
    </location>
    <perception>150</perception>
    <confidence>90</confidence>
    <known_exits>
      <refid>1</refid>
      <refid>2</refid>
    </known_exits>
  </individual>
  <individual>
    <type>NORMAL_PERSON</type>
    <location>
      <xloc>250</xloc>
      <yloc>305</yloc>
    </location>
  </individual>
</simulator>
```



```

        </location>
        <perception>150</perception>
        <confidence>70</confidence>
    </individual>
    <fire>
        <location>
            <xloc>240</xloc>
            <yloc>475</yloc>
        </location>
    </fire>
</simulator>

```

A.2 Sample Output of a Log file recorded during a Single Simulation Session

```

Session_Start
Simulation_Start_Time=>1336884656433
Event=>Start:AgentID=>NORMAL_PERSON_0:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>300_200
Event=>Start:AgentID=>FIRE_WARDEN_1:AgentClass=>examples.fire.simulation2.process.Ind
ividualAgent:AgentType=>FIRE_WARDEN:StartTime=>1336884656433:Location=>250_125
Event=>Start:AgentID=>NORMAL_PERSON_2:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>250_105
Event=>Start:AgentID=>NORMAL_PERSON_3:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>270_145
Event=>Start:AgentID=>NORMAL_PERSON_4:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>225_125
Event=>Start:AgentID=>NORMAL_PERSON_5:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>305_175
Event=>Start:AgentID=>NORMAL_PERSON_6:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>285_155
Event=>Start:AgentID=>NORMAL_PERSON_7:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>275_150
Event=>Start:AgentID=>NORMAL_PERSON_8:AgentClass=>examples.fire.simulation2.process.
IndividualAgent:AgentType=>NORMAL_PERSON:StartTime=>1336884656433:Location=>295_160
Event=>Start:AgentID=>FIRE_WARDEN_9:AgentClass=>examples.fire.simulation2.process.Ind
ividualAgent:AgentType=>FIRE_WARDEN:StartTime=>1336884656433:Location=>335_185
Event=>Start:AgentID=>FIRE_AGENT_0:AgentClass=>examples.fire.simulation2.process.Fir
eAgent:StartTime=>1336884656433:Location=>240_275
Event=>Exit:AgentID=>FIRE_WARDEN_9:AgentClass=>examples.fire.simulation2.process.Ind
ividualAgent:ExitTime=>1336884706593:ExitLocation=>450_200:ExitSource=>2
Event=>Exit:AgentID=>FIRE_WARDEN_9:AgentClass=>examples.fire.simulation2.process.Ind
ividualAgent:ExitTime=>1336884706593:ExitLocation=>450_200:ExitSource=>2
Event=>Exit:AgentID=>NORMAL_PERSON_2:AgentClass=>examples.fire.simulation2.process.I
ndividualAgent:ExitTime=>1336884714132:ExitLocation=>100_150:ExitSource=>1
Event=>Exit:AgentID=>NORMAL_PERSON_6:AgentClass=>examples.fire.simulation2.process.I
ndividualAgent:ExitTime=>1336884713637:ExitLocation=>100_150:ExitSource=>1
Event=>Exit:AgentID=>FIRE_WARDEN_1:AgentClass=>examples.fire.simulation2.process.Ind
ividualAgent:ExitTime=>1336884717641:ExitLocation=>100_150:ExitSource=>1
Event=>Exit:AgentID=>NORMAL_PERSON_4:AgentClass=>examples.fire.simulation2.process.I
ndividualAgent:ExitTime=>1336884719141:ExitLocation=>100_150:ExitSource=>1
Event=>Exit:AgentID=>NORMAL_PERSON_7:AgentClass=>examples.fire.simulation2.process.I
ndividualAgent:ExitTime=>1336884720631:ExitLocation=>100_150:ExitSource=>1
Event=>Exit:AgentID=>NORMAL_PERSON_8:AgentClass=>examples.fire.simulation2.process.I
ndividualAgent:ExitTime=>1336884739127:ExitLocation=>100_150:ExitSource=>1

```

In the sample log output, the value against “**Simulation_Start_Time**”, indicates the time which the fire started (Note that all timestamps in the log are produced using *System.currentTimeMillis()* call provided by java language).

Note that there are records starting with prefix **“Event=>Exit”** at the end of the log (each record carries 2 lines). Such **“Event=>Exit”** record indicates an exit of a particular individual with corresponding timestamp and exit location identifier. The elapsed times in milliseconds (found in Tables under Appendix B.3, Appendix B.4, Appendix C.3 and Appendix C.4) are calculated by taking the difference of **“ExitTime=>”** value (in an **“Event=>Exit”** record) and **“Simulation_Start_Time”** value.



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Appendix B:

Evaluation: Experiment 1(Scenario with 10 Individuals)

B.1 Input Scenario File

```
<?xml version="1.0"?>
<simulator>
  <exit>
    <id>1</id>
    <location>
      <xloc>100</xloc>
      <yloc>350</yloc>
    </location>
  </exit>
  <exit>
    <id>2</id>
    <location>
      <xloc>450</xloc>
      <yloc>400</yloc>
    </location>
  </exit>
  <individual>
    <type>NORMAL_PERSON</type>
    <location>
      <xloc>300</xloc>
      <yloc>400</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
  </individual>
  <individual>
    <type>FIRE_WARDEN</type>
    <location>
      <xloc>250</xloc>
      <yloc>325</yloc>
    </location>
    <perception>150</perception>
    <confidence>90</confidence>
    <known_exits>
      <refid>1</refid>
      <refid>2</refid>
    </known_exits>
  </individual>
  <individual>
    <type>NORMAL_PERSON</type>
    <location>
      <xloc>250</xloc>
      <yloc>305</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
  </individual>
  <individual>
```



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```

<type>NORMAL_PERSON</type>
<location>
  <xloc>270</xloc>
  <yloc>345</yloc>
</location>
<perception>150</perception>
<confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>225</xloc>
    <yloc>325</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>305</xloc>
    <yloc>375</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>285</xloc>
    <yloc>355</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>275</xloc>
    <yloc>350</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>295</xloc>
    <yloc>360</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>FIRE_WARDEN</type>
  <location>
    <xloc>335</xloc>

```



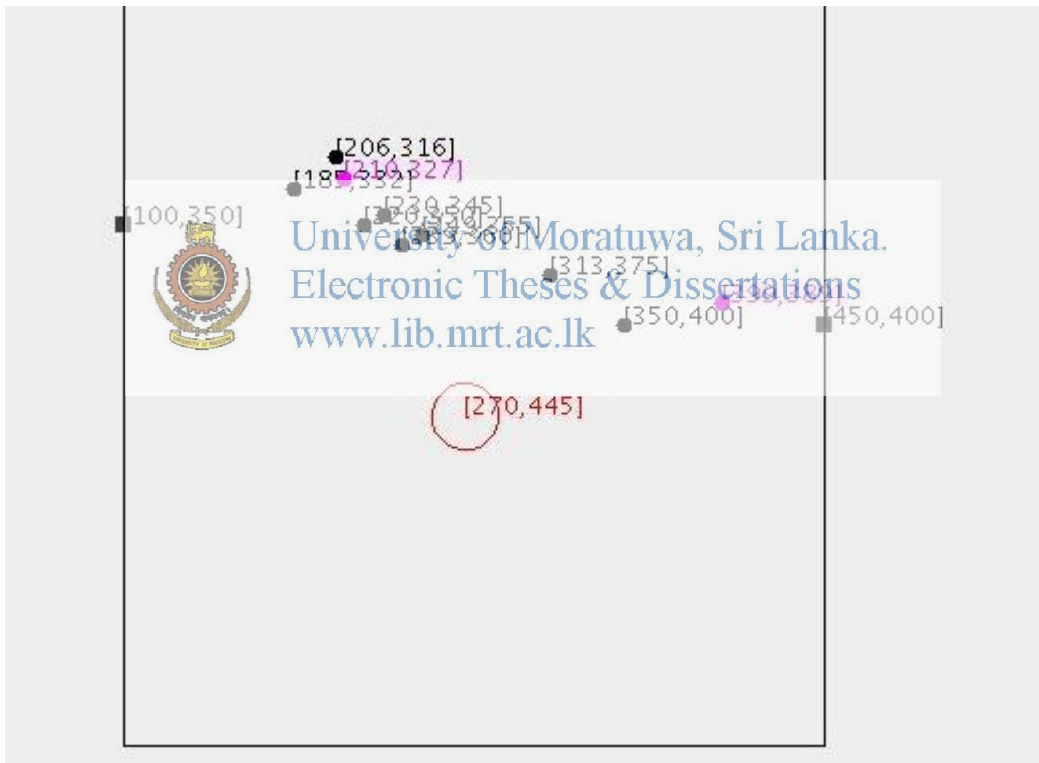
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```

        <yloc>385</yloc>
    </location>
    <perception>150</perception>
    <confidence>90</confidence>
    <known_exits>
        <refid>1</refid>
        <refid>2</refid>
    </known_exits>
</individual>
<fire>
    <location>
        <xloc>270</xloc>
        <yloc>445</yloc>
    </location>
</fire>
</simulator>

```

B.2 Example Screen Shot



Note that the center of fire source is at [270,455]. “Exit 1” referred in Table B.3 and Table B.4, is the left hand side exit location which is at [100, 350]. “Exit 2” is the right hand side exit location which is at [450, 400]. Note that individuals in locations [399, 389] and [210, 327] are fire wardens. All the other individuals are ordinary people.

B.3 Cumulative Statistics derived based on Log file – 1st Simulation Session

Time elapsed since Fire Started (in milliseconds)	Cumulative Individual Count at Exit 1	Cumulative Individual Count at Exit 2	Total Cumulative Individual Count at Both Exits
48501	1	0	1
50160	2	0	2
57204	2	1	3
57699	2	2	4
61208	2	3	5
62708	2	4	6
64198	2	5	7
82694	2	6	8
87654	2	7	9
108727	2	8	10

B.4 Cumulative Statistics derived based on Log file – 2nd Simulation Session

Time elapsed since Fire Started (in milliseconds)	Cumulative Individual Count at Exit 1	Cumulative Individual Count at Exit 2	Total Cumulative Individual Count at Both Exits
55212	1	0	1
57289	2	0	2
62300	2	1	3
64774	2	2	4
64812	2	3	5
65271	2	4	6
68295	2	5	7
68331	2	6	8
83825	2	7	9
89317	2	8	10

Appendix C:

Evaluation: Experiment 2(Scenario with 30 Individuals)

C.1 Input Scenario File

```
<?xml version="1.0"?>
<simulator>
  <exit>
    <id>1</id>
    <location>
      <xloc>100</xloc>
      <yloc>350</yloc>
    </location>
  </exit>
  <exit>
    <id>2</id>
    <location>
      <xloc>450</xloc>
      <yloc>275</yloc>
    </location>
  </exit>

  <individual>
    <type>FIRE_WARDEN</type>
    <location>
      <xloc>193</xloc>
      <yloc>245</yloc>
    </location>
    <perception>150</perception>
    <confidence>90</confidence>
    <known_exits>
      <refid>1</refid>
      <refid>2</refid>
    </known_exits>
  </individual>
  <individual>
    <type>NORMAL_PERSON</type>
    <location>
      <xloc>280</xloc>
      <yloc>256</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
  </individual>
  <individual>
    <type>NORMAL_PERSON</type>
    <location>
      <xloc>373</xloc>
      <yloc>235</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
  </individual>

```



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```

<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>234</xloc>
    <yloc>273</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>251</xloc>
    <yloc>220</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>

<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>174</xloc>
    <yloc>348</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>294</xloc>
    <yloc>210</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
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    <yloc>267</yloc>
  </location>
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  <confidence>70</confidence>
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  <location>
    <xloc>270</xloc>
    <yloc>230</yloc>
  </location>
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  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>

```



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```

    <location>
      <xloc>270</xloc>
      <yloc>295</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
  </individual>

<individual>
  <type>NORMAL_PERSON</type>
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    <yloc>283</yloc>
  </location>
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  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
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    <yloc>177</yloc>
  </location>
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  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>232</xloc>
    <yloc>239</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>349</xloc>
    <yloc>281</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>182</xloc>
    <yloc>177</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>

<individual>
  <type>FIRE_WARDEN</type>
  <location>

```



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```

        <xloc>285</xloc>
        <yloc>300</yloc>
    </location>
    <perception>150</perception>
    <confidence>90</confidence>
    <known_exits>
        <refid>1</refid>
        <refid>2</refid>
    </known_exits>
</individual>
<individual>
    <type>NORMAL_PERSON</type>
    <location>
        <xloc>207</xloc>
        <yloc>124</yloc>
    </location>
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    <confidence>70</confidence>
</individual>
<individual>
    <type>NORMAL_PERSON</type>
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    </location>
    <perception>150</perception>
    <confidence>70</confidence>
</individual>
<individual>
    <type>NORMAL_PERSON</type>
    <location>
        <xloc>324</xloc>
        <yloc>268</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
</individual>
<individual>
    <type>NORMAL_PERSON</type>
    <location>
        <xloc>354</xloc>
        <yloc>234</yloc>
    </location>
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    <confidence>70</confidence>
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<individual>
    <type>NORMAL_PERSON</type>
    <location>
        <xloc>129</xloc>
        <yloc>165</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
</individual>
<individual>

```



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```

<type>NORMAL_PERSON</type>
<location>
  <xloc>138</xloc>
  <yloc>236</yloc>
</location>
<perception>150</perception>
<confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>346</xloc>
    <yloc>147</yloc>
  </location>
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  <confidence>70</confidence>
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    <yloc>321</yloc>
  </location>
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  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>174</xloc>
    <yloc>253</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>

<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>188</xloc>
    <yloc>138</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>
    <xloc>198</xloc>
    <yloc>148</yloc>
  </location>
  <perception>150</perception>
  <confidence>70</confidence>
</individual>
<individual>
  <type>NORMAL_PERSON</type>
  <location>

```



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```

        <xloc>116</xloc>
        <yloc>163</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
</individual>
<individual>
    <type>NORMAL_PERSON</type>
    <location>
        <xloc>126</xloc>
        <yloc>143</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
</individual>
<individual>
    <type>NORMAL_PERSON</type>
    <location>
        <xloc>158</xloc>
        <yloc>171</yloc>
    </location>
    <perception>150</perception>
    <confidence>70</confidence>
</individual>

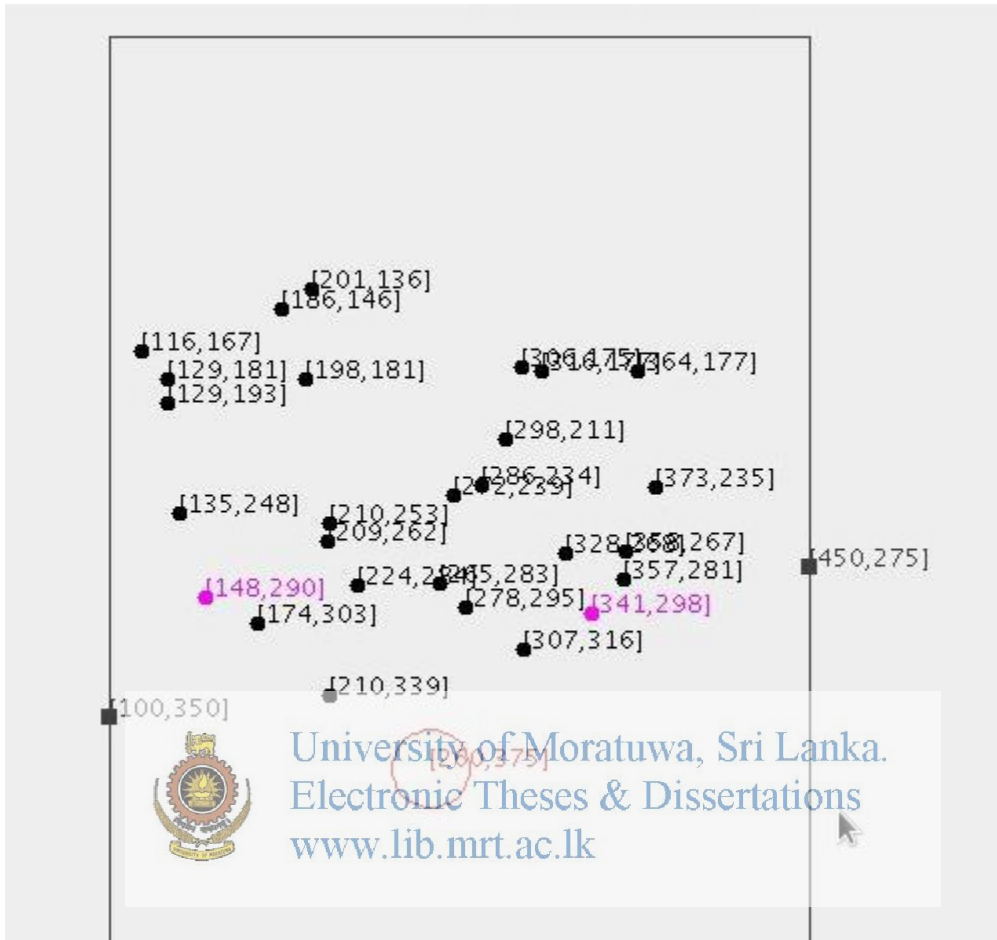
<fire>
    <location>
        <xloc>260</xloc>
        <yloc>375</yloc>
    </location>
</fire>
</simulator>

```



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C.2 Example Screen Shot



Note that the center of fire source is at [260,375]. “Exit 1” referred in Table C.3 and Table C.4, is the left hand side exit location which is at [100, 350]. “Exit 2” is the right hand side exit location which is at [450, 275]. All other points in the middle denote the location of the each individual at the time this screenshot was taken.

C.3 Cumulative Statistics derived based on Log file – 1st Simulation Session

Time elapsed since Fire Started (in milliseconds)	Cumulative Individual Count at Exit 1	Cumulative Individual Count at Exit 2	Total Cumulative Individual Count at Both Exits
43393	0	1	1
48260	1	1	2
48267	1	2	3
54308	1	3	4
58385	2	3	5
62902	2	4	6
65893	2	5	7
66290	2	6	8
66904	3	6	9
66937	4	6	10
66981	5	6	11
67081	6	6	12
68975	6	7	13
70885	6	8	14
71477	6	9	15
76507	7	9	16
79385	8	9	17
79862	8	10	18
82881	9	10	19
85370	10	10	20
87428	10	10	21
90464	12	10	22
91157	13	10	23
91225	14	10	24
100509	15	10	25
104981	15	11	26
112011	16	11	27
113964	17	11	28
145927	17	12	29

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C.4 Cumulative Statistics derived based on Log file – 2nd Simulation Session

Time elapsed since Fire Started (in milliseconds)	Cumulative Individual Count at Exit 1	Cumulative Individual Count at Exit 2	Total Cumulative Individual Count at Both Exits
37864	1	0	1
42495	2	0	2
52460	3	0	3
59786	3	1	4
60860	4	1	5
63226	5	1	6
63497	5	2	7
73958	6	2	8
73967	7	2	9
73969	7	3	10
74930	8	3	11
74948	9	3	12
75431	10	3	13
75512	11	3	14
75617	11	4	15
75851	11	5	16
75867	11	6	17
75883	11	7	18
75965	12	7	19
76389	13	7	20
84577	14	7	21
84902	14	8	22
85954	15	8	23
87931	16	8	24
89902	17	8	25
91970	17	9	26
92046	18	9	27
95546	19	9	28
101981	20	9	29
102027	21	9	30



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