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Improvements in Simulation of Virtual Ant's Behaviour

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Abstract:

This paper shows a new approach to the simulation of virtual ant's behaviour and results of many simulations. The presented system is revamped and adjusted to mechanical principles which are more general. In the simulation, Newton's laws of motion are applied. The results of the simulations confirm the success of selected approach.

Keywords:

Ant behaviour, flock intelligence, simulation.

1. Introduction

In the future conflicts it can be expected that the war area will be dehumanized because the using of mobile robotics battle and support systems (with different levels of autonomy) is assumed. This creates a problem how to improve control of autonomous mobile robots (so-called unmanned robotic vehicles) in the mission. One of possible approaches is to use simulation of ant's colony behaviour.

The ant colony can be understood as an intelligent entity and its behaviour can be utilized as a methodology for motion organization of physical entities.

This methodology is based on the behaviour of natural ants searching for food and marking the way back to the anthill by chemical pheromone. This activity gives a notice for other ants.

According to the approach of Parunak et al. the virtual ants – so-called mobile agents – analogously move in a digital pheromone field [1-4]. This field corresponds to the real environment and it is created by the net of places – so-called stationary agents – and performs pheromone aggregation, evaporation and diffusion. Mobil agent deposits pheromone into the place, determines the relative strength of given flavour at the place and at each of this neighbours and it moves to another place by spinning a roulette wheel whose segments are weighted according to this set of strengths. After

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certain number of iterations, the optimal way between the starting point and the goal point is found.

Further study of natural ant’s behaviour showed that ants use not only pheromone for navigation. For this reason the original approach of Dorigo et al. [8] was – in several studies – modified for instance with using other methods of combinatorial optimization for solving the ant colonies metaphor or by simulation of colony ants behaviour [9, 10]. Just the second way introduced by Merloti [11] served the authors as an inspiration for the presented solution of virtual ant’s behaviour based on combination of continuous and event driven system simulation.

2. Technical Background

Based on previous experience we have decided to revamp the system. There were noticeable changes as follows:

No More Discrete Pheromones Array

Discrete pheromone array (usually presented as a matrix) is memory space waste. When long distances between the starting and destination points were tested, a serious problem with computer performance appeared. There is a possibility to store pheromones as isolated units.

Mechanical Approach

An ant moving is now determined by the equations of motion

$$\frac{\mathrm{d}^2 \boldsymbol{s}}{\mathrm{d}t^2} = \frac{1}{m}\sum_{\forall i} \boldsymbol{F}_i \qquad (1)$$

$\boldsymbol{F}_i = \boldsymbol{F}_i(t)$ is force, $\boldsymbol{s} = \boldsymbol{s}(t)$ is ant position and m (mass) has a unit value in the simulation. Using mechanical behaviour we can easily expand the simulation by obstacles, slowing areas etc.

3. Simulation Objects

In the simulation 7 types of objects were used: Source and Destination, Enemy item (obstacle), Normal pheromone, Forcered pheromone, Searcher (ant) and Forcerer (ant). All construct will be explained below.

Source and Destination

Those two objects mark the starting point (nest) and the goal (food) in simulation. Source point generates in specified time interval Searchers. Fig. 1 shows which symbols are used in simulation visualisations.

Fig. 1 Symbols for Source and Destination

Obstacles – Enemies

Obstacles are presented in the simulation (in the current state of experiments) as points. Any obstacle acts as a force source to any near ant.

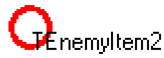

Fig. 2 Symbol for obstacle – enemy in simulation

Normal and Forcered Pheromone

Normal and Forcered pheromone (Forcered pheromone is result of Forcerer activity – see bellow) acts as information storage. In both cases the information evaporates in time and can be increased by ants (see Searcher and Forcerer). Fig. 3 shows the symbols for pheromones visualization. Darkness corresponds to pheromone intensity. Pheromone intensity is decreased in time. Darker pheromone has higher intensity. Forcered pheromones are very important for Searchers because they act as navigators.

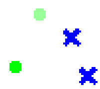

Fig. 3 Normal (circle) and Forcered (cross) pheromones

Searcher

Searcher is an ant that "is searching for" the destination. Its moving is determined by Forcered pheromones (those are in the line of sight – the line of sight is determined by velocity vector) and Enemy items (see Enemy item). Each object acts (towards Searcher) as a force source. The sum of those forces is used for determination of Searcher moving.

Searcher is trying (in specified time intervals) to put Normal pheromone. In this event Searcher at first tries to find the nearest pheromone and if there is not any, he creates a new one. If there is any, it increases its level.

If Searcher reaches the Destination, a new ant will be born – Forcerer, and this Searcher is dying. If Searcher does not reach Destination in a specified time interval (life time), it will die.

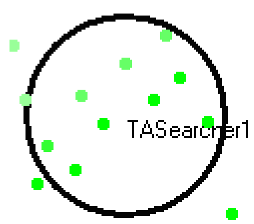

Fig. 4 Searcher ant in simulation

Forcerer

Forcerer is the name of ants which are moving from Destination to Source. Forcerer got information about source location from Searcher. He is trying to put pheromone on the way. If there is any normal pheromone, it will change it to Forcered pheromone. If Forcered pheromone is already lying here, it will increase its value. If here is not any pheromone, it will put one Normal pheromone.

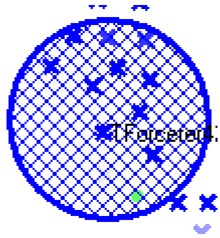

Fig. 5 Forcerer ant in simulation

4. Experiments

We made some sort of experiments that are based on the rules described above. All experiments were made in a program developed by the authors.

4.1. Basic Experiments

The goal of the first experiment was to test the behaviour of single entities.

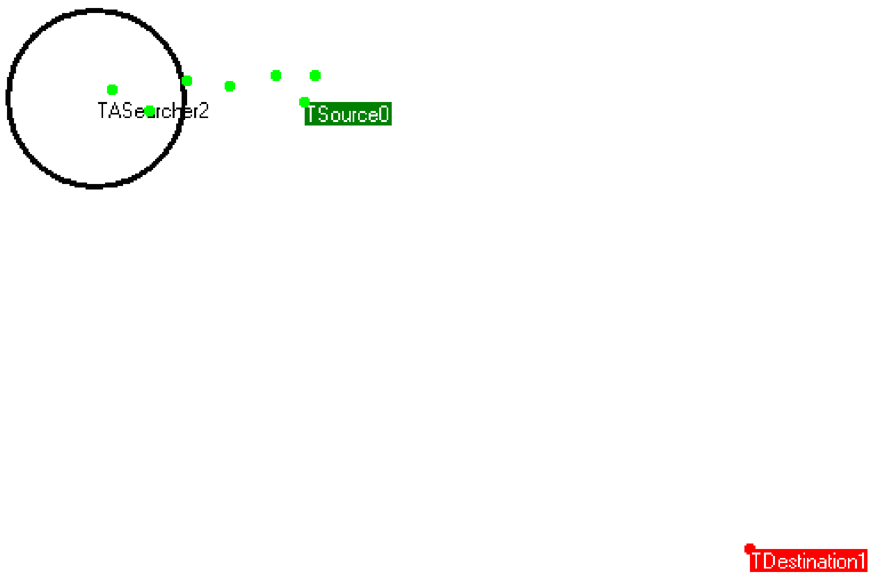

Fig. 6 Beginning of the simulation

This figure shows the state of simulation at the beginning. This simulation is the easiest. There is only Source and Destination.

Fig. 7 shows the state of simulation after about 500 s. We can see a path marked by crosses. There are Searchers (no 46, 127, 12, 224). They are trying to find the path to the Destination. 2 Forcerers are walking from destination to source marking the path by Forcered pheromones (two ants filled with cross style).

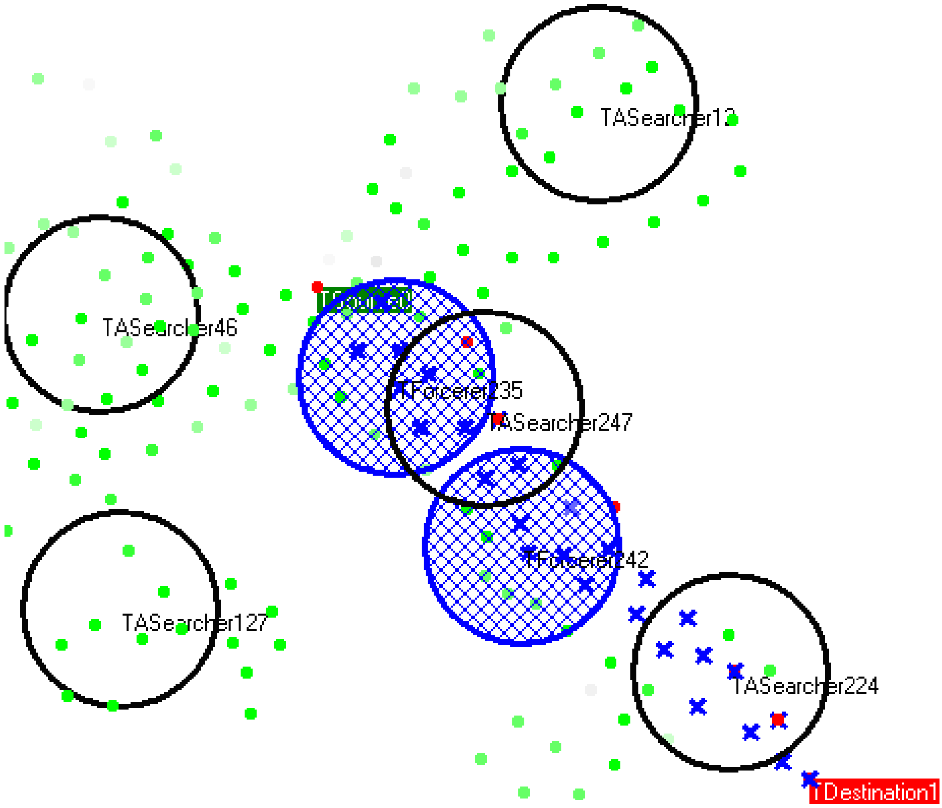

Fig. 7 Snap of simulation after approx. 500s

Even after 3500 s of simulation time there are still some Searcher ants searching another path (Searcher 221 in the upper right corner) – see Fig. 8. Existence of Searchers in other areas (Searchers trying to find another path to destination) is good for adaptation. When the problem constraints will change the ants will adapt and will find a new solution. The radius of random searching depends on Searchers life time (see Searcher in part 2).

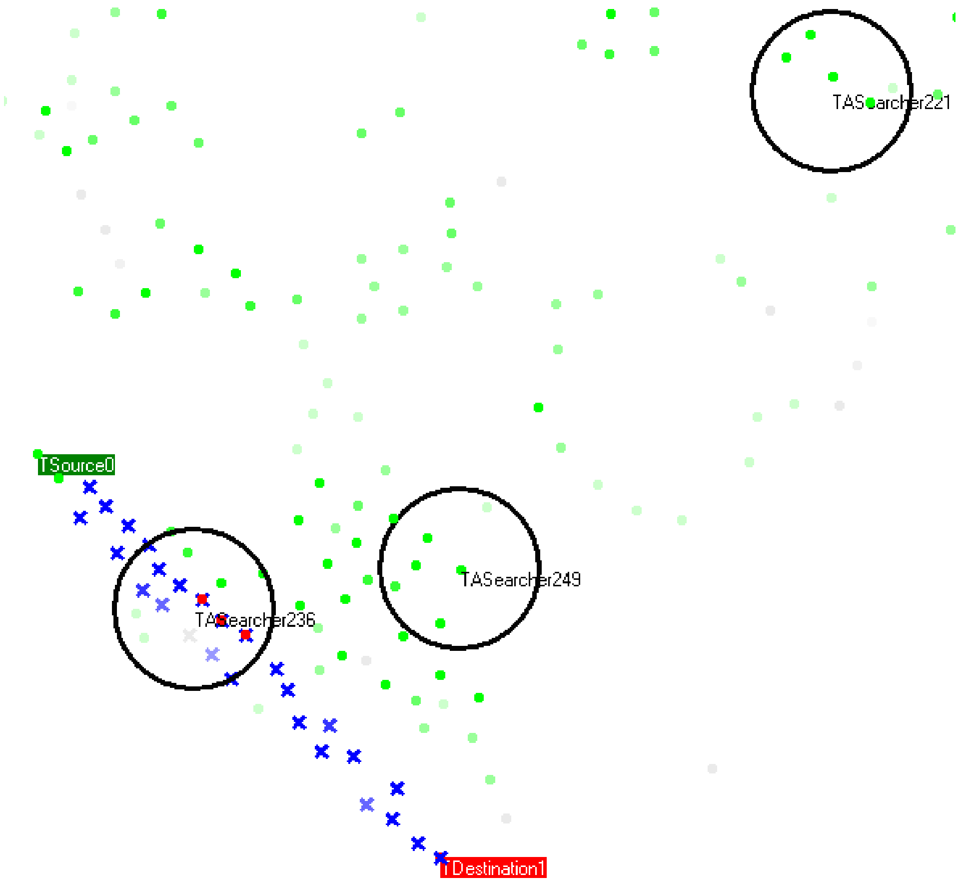

Fig. 8 Snap of simulation after approx. 3500 s

4.2. Experiments with Obstacles

Next experiments were made with obstacles implementation. Two basic types of avoiding obstacles were tested. First one is simple avoiding obstacles – see Fig. 9. The second one is running through corridor – see Fig. 10.

The ability to solve complex problems with obstacles is dependent on the life time of Searchers. Searchers have to reach destination before they die and first Searcher has to reach it by random way (longest time is needed). When the first Searcher reaches the Destination, the problem solution gets big progress because there will be the first Forcerer and he will mark first Forcered pheromones (crosses on figures). Forcered pheromones are main information for Searcher orientation and moving.

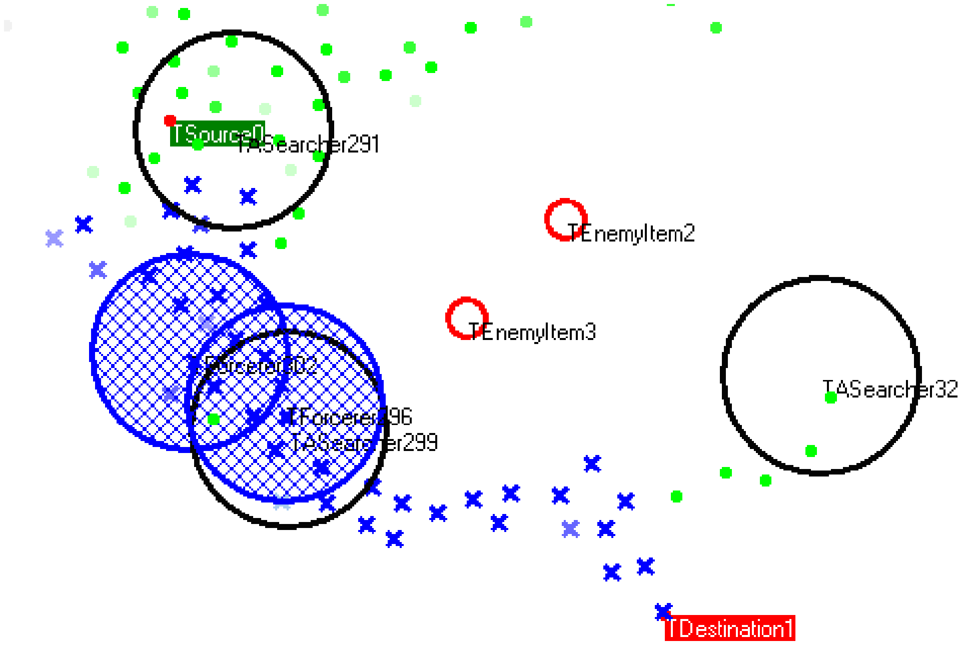

Fig. 9 Snap of simulation with two obstacles

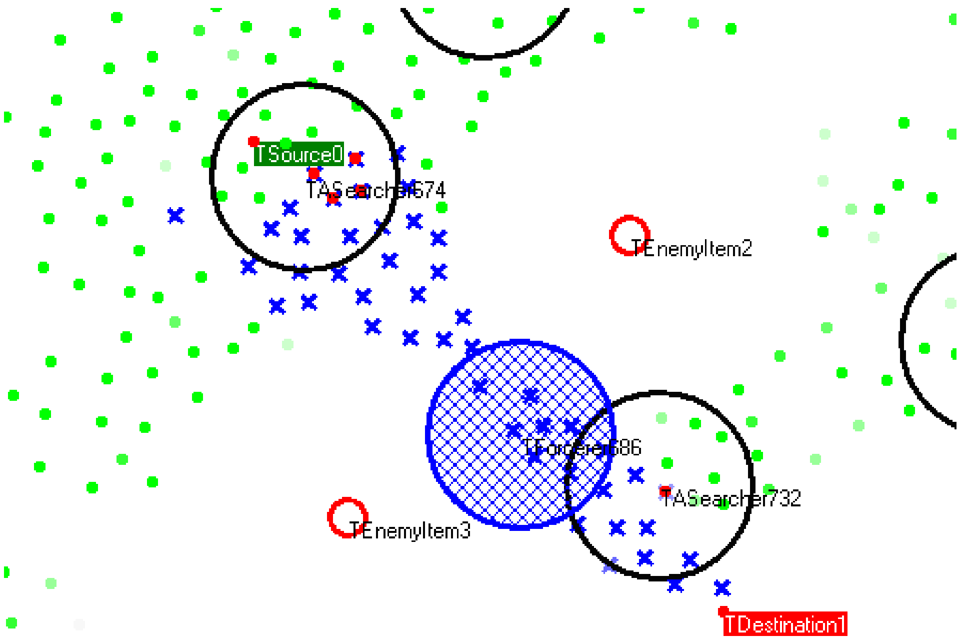

Fig. 10 Snap of simulation with two obstacles (corridor)

5. Conclusion

This paper presents a simulator for an experiment with virtual ants. A well- known approach has been changed. The reasons for these changes were:

1. Duration of simulations – all presented simulations have the same parameters and are shorter than 10 minutes (there is one exception – Fig. 8 where the simulation progression is shown).

2. Possibility to implement obstacles and avoiding – other experiments with obstacles used pheromones with different flavour. In the presented simulation is used only one pheromone flavour and the simulations still can accept multiple obstacles.

Now we are looking for the next goal – implementing dangerous areas and slowing areas. This aspect allows a better description of the situation on the battlefield.

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