Parallel Evaluation of Coefficients for a Navigation System with GPU

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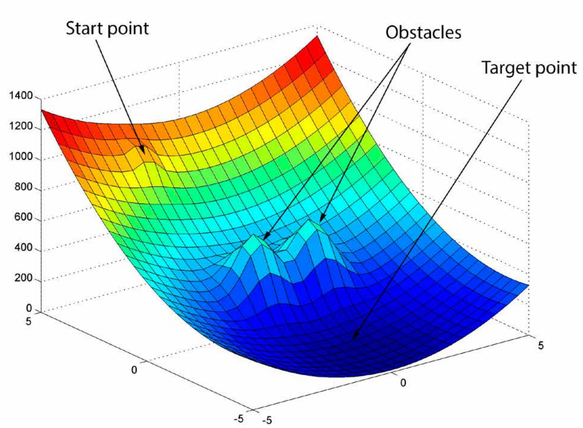
Motivation

There is a demand for autonomous mobile robots in various fields of application, such as material transport, cleaning, monitoring, guiding people and military applications. These mobile robots must interact with their environment, and make decisions in a considerable fast time to accomplish their tasks.

Basic Idea

This work presents the implementation of parallel evaluation of coefficients for a navigation system providing a solution in the navigation area of autonomous mobile robots. The idea is make use of parallel computation as a tool to improve the performance and accelerate the evaluation of the coefficients in the system, which is based on the method of the Artificial Potential Field (APF) and the Genetic Algorithms (GA).

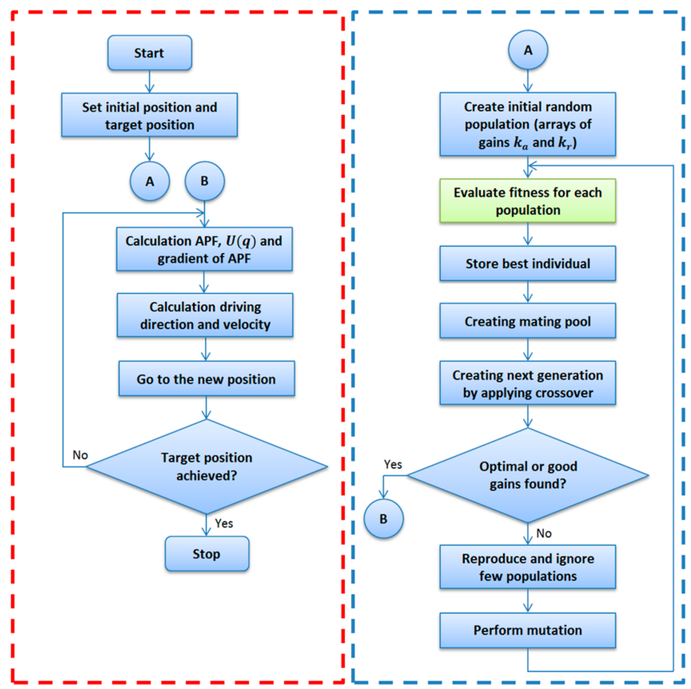


The main idea of the method of the APF is to establish an attractive potential field force around the target point (valley), as well as to establish a repulsive potential field force around obstacles (hills), as is shown in the figure above. The two potential fields together (attractive +repulsive) form the total potential field called APF:

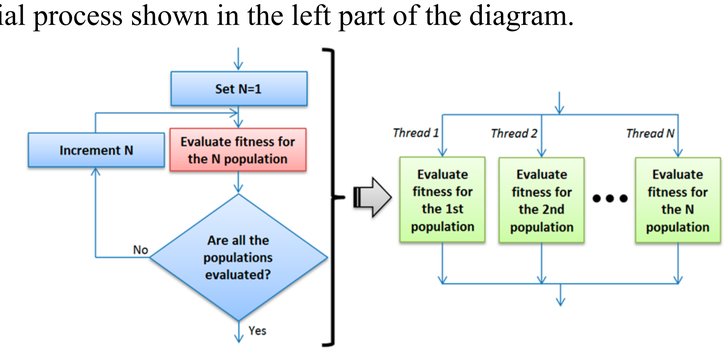
$$U(q) = \frac{1}{2}k_a(q-q_f)^2 + \sum_{i=1}^{n}\left(\frac{1}{2}k_r\left(\frac{1}{\rho}-\frac{1}{\rho_0}\right)^2\right)_i$$

Algorithm

The coefficients k_a and k_r are unknown, to know the solution for this coefficients we use a GA that is shown in the right part of the next diagram. When the right coefficients are found by the GA, the navigation is performed by the left part of the diagram.

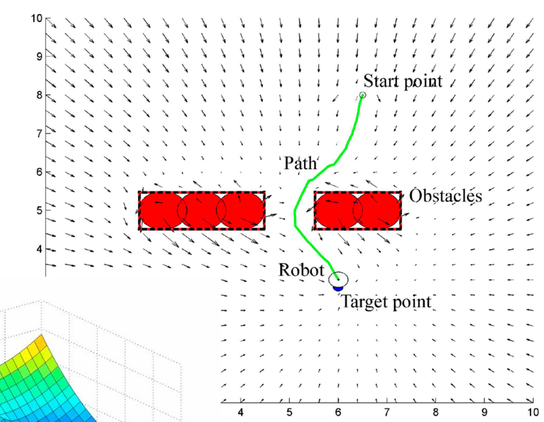


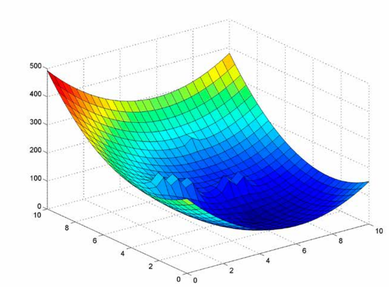
In the next diagram it can be seen the parallelized evaluation process, where the evaluation of each subpopulation of coefficients is running on a thread and thus for making the evaluation simultaneously or parallel, giving runtime advantages over the sequential process shown in the left part of the diagram.



Results

The implementation of the evaluation was on a GeForce GTX 760. The figure below shows the simulation of the navigation in a specific mission for the robot, where the robot successfully reached the target point. The table below shows the time comparison between different platforms of implementation.





Evaluation in Sequential form (Matlab)	Evaluation in Sequential form (C++)	Evaluation in Parallel form (C++)	Evaluation in Parallel form (CUDA)
4.8832s	1.6284s	1.1099s	0.1389s

Conclusion

- This work presents a novel implementation for robot navigation.
- With the combination of the APF method and the GA was possible the development of an intelligent system for navigation in mobile robotics.
- Presented implementation on GPU achieves best time of computation for the coefficients making the implementation suitable for applications in the real world.