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Optimization technique for path finding robot using soft core processor

Dheeraj D. Jain, Vilas V. Deotare, Dinesh Padole

***Abstract*— There are many algorithms for path finding robot and many optimization techniques applied for different parameters and their architectures, but this paper explains how software parameters affect performance of path finding robot and after applying optimization technique the parameters performance can be improved. The optimization techniques like genetic algorithm (GA) gives optimized values of software parameters used in fitness function. The novel thing is that the whole application is designed using hardware software co-design which enhances the performance of those attributes which are not beneficial in hardware as well as software design. The resources required for this co-design is less than that of hardware and this improves the performance.**

Index Terms*— Optimization technique, Path finding robot, Soft core processors.

I. Introduction

In robotics a lot of development is going on. Robotics is trending all over the world because of its applications which are there in each and every field. In case of application specific areas the automation is essential one. The main objective of researchers is to optimize area, cost and power consumption, accuracy and speed. There are many ways to achieve the above mentioned objectives. These objectives can be using different architectures, algorithms, hardware and software. The hardware used for this application is either a FPGA or a microcontroller. The main disadvantage of using simply hardware to solve problem is it requires more power and another one is cost of hardware is more than that of the software. Some researchers have used just software part to solve the same problem but the ambiguities while using software is its speed is less and computational time is more as compared to hardware though the cost is less.

Artificial Intelligence is one of the solutions to give optimized path and obtain required results but the complexity increases and in dynamic environment the computational time may increase. So, to achieve the advantages of both hardware and software it's better to go with hardware – software co-design.

In the combination of these two, the application parameter can be optimized and will give balanced results. This paper explains how hardware- software co-design can be used for path finding application in static environment and it shows optimized and balanced results.

There are many optimization algorithms one can use Multi attribute Decision Making (MADM) when there is single objective and having multiple attributes and multiple alternatives. But Multi objective Decision Making (MODM) techniques are used to achieve multiple objectives from one application. For particular problem already so many MODM techniques have been used along with their improved versions. But in this paper we have used genetic algorithm (GA) optimization algorithm which has shown better results for maximum functions and applications as proved

II. Related Work

For the application of path finding mobile robot many researchers have done experiment with different hardware, software and algorithms. The path finding system can be implemented using FPGA along with artificial intelligence and HPO-PSO algorithm witch gives better results as compared to previous implementations [1]. In the next paper the 2-D cell architecture has been presented for the Euclidean distance Transform (EDT) and Nearest Neighbor Transform (NNT) for operating at high speed [2]. In this technique the image of arena is captured by camera mounted on top after that the image is converted into binary image and then using EDT and NNT shortest path is calculated. Optimization is the field of research where each and every attribute of application can be optimized depending on its limits.

The genetic FPGA implementation for path planning of autonomous mobile robot gives optimized results and Genetic algorithm (GA) works perfecty even if an environment is unknown [3]. A Modified Particle Swarm Optimizer (MPSO) algorithm is used to find optimal path for the mobile robot in working environment with obstacles is capable of effectively guiding a robot moving from start position to the goal position in complex environment and find optimum/shortest path without colliding any obstacles in the environment. [4]. However, it takes a lot of time to get the solution and it is not too easy to obtain the optimal path every time. It is also difficult to apply to the complex and big size maps so ACO algorithm are changed to converge into the optimal solution rapidly when a certain number of iterations have been reached [5].

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III. HARDWARE AND SOFTWARE DESCRIPTION

➢ *FPGA Concept*

The architecture is developed with Pico blaze soft core processor. The FPGA kit used is Xilinx Spartan 3E-500 FG320 which has 16 MB flash memory inbuilt. FPGAs contain an array of programmable logic blocks, and a hierarchy of reconfigurable interconnects that allow the blocks to be wired together, many logic gates that can be inter-wired in different configurations. Logic blocks can be configured to perform complex combinational functions, or merely simple logic gates like AND and XOR as shown in fig.1 [6]

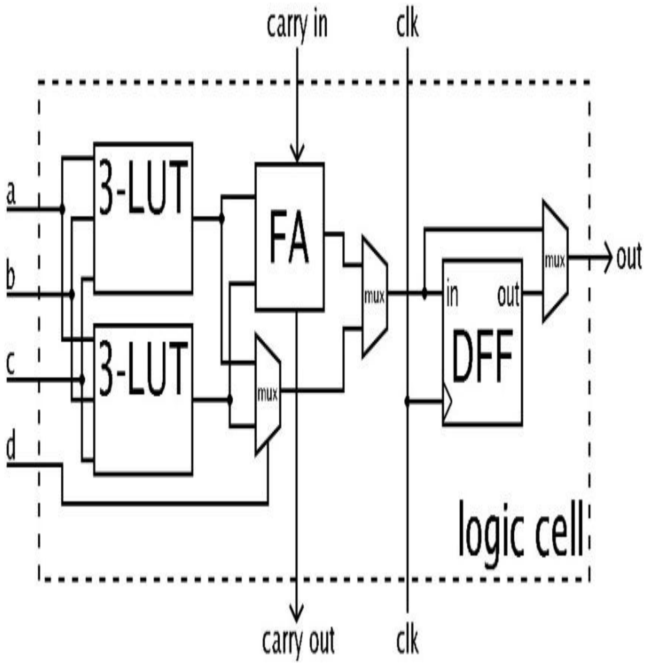

Fig.1 Logic cell in FPGA

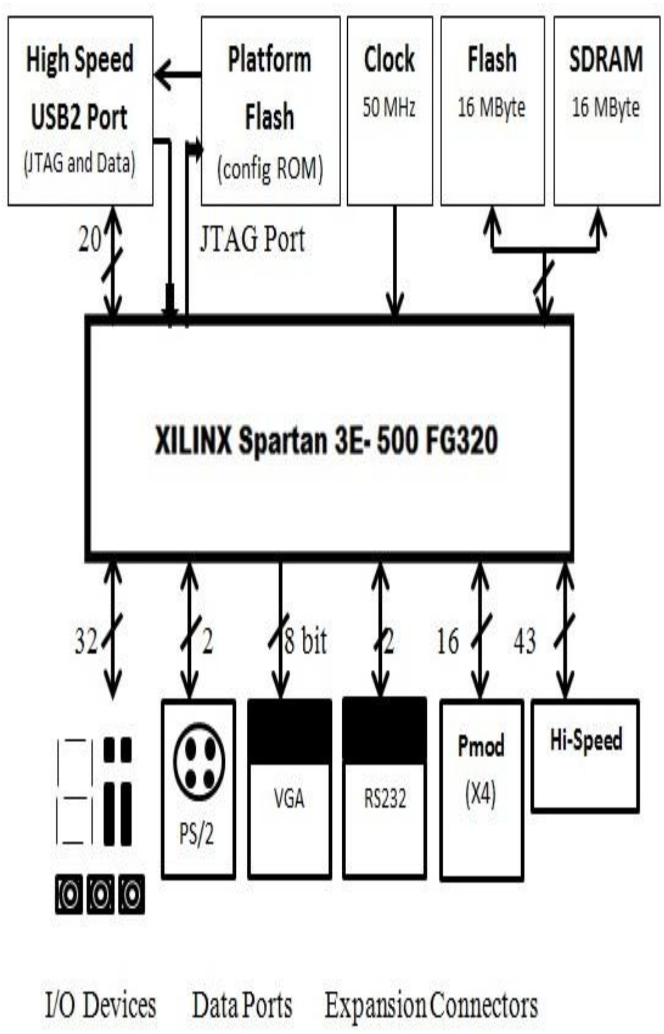

Fig.2 Architecture of Spartan 3E

➢ *RS – 232*

In communications, RS-232 is a standard for serial communication or for transmission of data. It formally defines the signals connecting between a DTE (data terminal equipment) such as a computer terminal, and a DCE (data circuit-terminating equipment, originally defined as data communication equipment like any embedded or VLSI kit.

➢ *Software used*

The all software part is implemented on computer where path finding algorithm runs as well as the virtual environment is seen and traced path can be evaluated.

The Xilinx 8.01i is used to simulate the code and implement on hardware. Eyesim simulator is used to create virtual environment and the path and robot behavior can be seen on this simulator.

IV. METHODOLOGY

The whole system behavior is described here. The Spartan kit is connected to computer through RS-232 serial cable and USB cable which become medium of communication between two devices in which, the code is implemented on hardware using USB cable and further communication is done by RS-232 cable.

The baud rate affects the serial communication. Here, in this particular application the baud rate should be in between 2400 to 11500, but we have kept it as 9600 as per our hardware requirements. After setting up an environment all VHDL files are run in Xilinx 8.01i. Soft core processor is used so that it consumes less power, cost as compared to hardware setup whereas it is more flexible as well as computational time is less than software setup, which adds advantages of both hardware and software as shown in fig.3.

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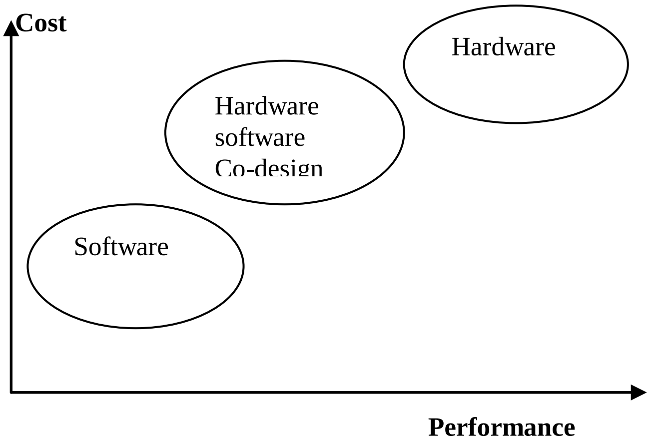

Fig.3 Hardware, Software and Hardwar Software co-design performance – cost graph

After running VHDL code, Eyesim simulator comes in picture where we have designed the virtual environment for path finding robot. There are some robot types which we can choose as per our requirements and applications. Robot finds path as per our coding and there are software parameters those affects for finding path those parameters are taken into considerations.

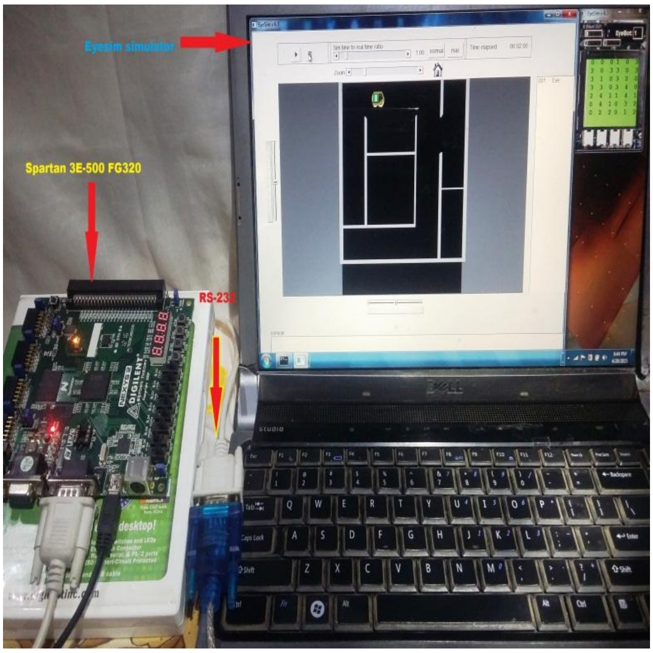

Fig.4 Validation Environment

In fig.4 the working environment is shown in which the path finding robot where the Eyesim simulator shows robot and (X, Y) position of robot along with that its hardware is shown. The optimization can be done by implementing optimization techniques to three main levels for this particular application.

The fig.5 shows where implementation of optimization techniques is suited and how it gives better results for this problem.

Optimization techniques can be implemented

- For its hardware architecture.
- For hardware parameters
- For software parameters

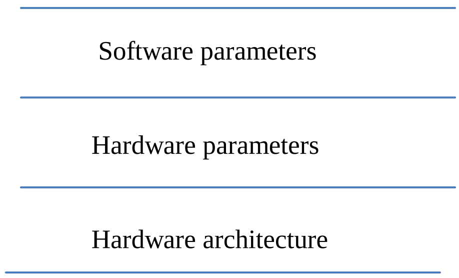

Fig.5 Levels for implementing optimization techniques

In this path finding application software parameters has been extracted and optimization technique is implemented. The extracted parameters and fitness function of software parameters are shown below equation.

$$F(x) = x1 * x2 \quad (1)$$

$$x1 = x3 * x4 \quad (2)$$

$$x2 = Pi * x3/2 \quad (3)$$

Where,

x1 - Speed of robot in vertical direction

x2 – Speed of robot while taking turn

x3 –Speed of robot in RPM

x4 – distance value i.e. distance between robot and arena

All above equations shows how the performance of path finding robot can be affected and how these parameters are interdependent. Pi value is required to convert radians to degree and vice versa. All the parameters are beneficial, so maximum values are preferred. After putting limits to all parameters optimum values are obtained to all parameters. Now Genetic algorithm is implemented to above fitness function as shown in eq. (1).

The Genetic Algorithm (GA) is implemented to above fitness function where all parameters of fitness are beneficial but while applying GA we have reversed the fitness function and applied GA where the function is treated as minimization problem. The results and resource utilization of hardware is described here.

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V. RESULTS

After applying GA to these software parameters we got results as shown in fig. 6. Here we minimize the values of fitness function and the values of two variables are taken up. The values of *x3* and *x4* are 892.545 and 0.999 respectively for this fitness function which shows better results as compared to their other values.

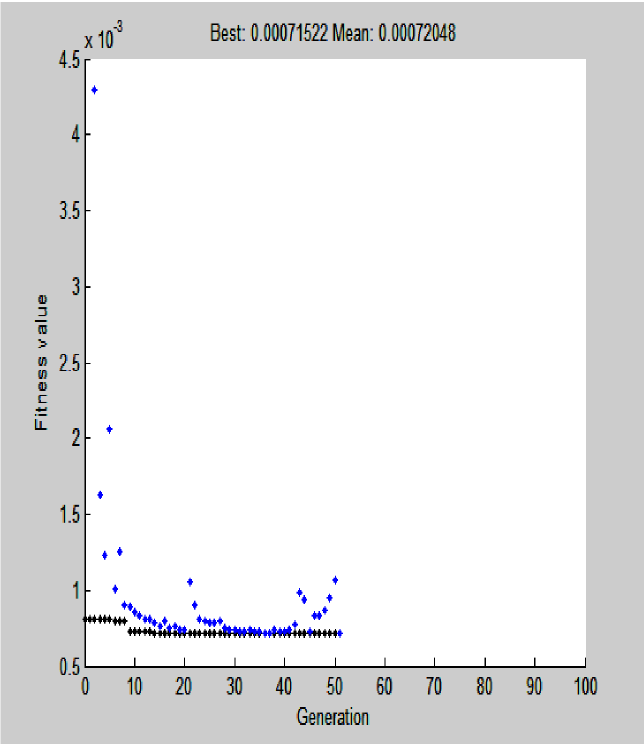

Fig. 6 Graph of Fitness value and Number of generations

The fig.6 shows the graph of fitness value and number of generations. It is minimized gradually and found values of two variables which affect the performance of path finding robot.

As we have used FPGA with hardware software co-design for this application one should see different aspects and parameters of hardware as well as software along with that here less resource are used and those are comparatively less than hardware design. Table no.1 shows clock frequency, time and RAM used as well as number of f/f used.

List of resources used	**Quantity**
Number of slice f/f	705 (7%)
4 input LUTs	597(6%)
RAM	16 * 1
Clocks	89.859 MHz
Time	11.546 ns

Table No.1 Number of resources utilized

VI. CONCLUSION

The path finding robot can be implemented with different ways and using different algorithms but ultimately software, hardware parameters and their optimum utilization is important. In this paper the optimization algorithm is applied to software parameters and the results are shown in fig.6. The different parameters are optimized and the hardware resource utilization is also shown which is very less as compared to other hardware designs. This shown the power consumption of application also reduced and cost can be minimized is application specific architecture is designed.

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Mr. Dheeraj D. Jain, PG scholar pursuing master degree from Pune University. He has completed his bachelor degree from WIT, Solapur University. Currently working in the area of optimization techniques like MADM and MODM methods.

Prof. Vilas V. Deotare completed Engineering from University of Pune. Post-Graduation from BAMU Aurangabad. He is pursuing Doctorate from Nagpur University (India). He is a member of Professional bodies like ISTE, His Research of Interest in VLSI and Development of soft computing algorithms in VLSI. He worked as a reviewer in IEEE conferences.

Prof. Dinesh Padole completed Engineering from RTM Nagpur, Post-Graduation from CEDTI Aurangabad & awarded as Doctorate from RTM Nagpur University. He is associated with Various professional societies like Member IEEE, life member ISTE and CSI. His research interest includes Multiprocessor /Multi-core systems, Embedded System Design. He worked as reviewer & Chaired technical sessions for several International conferences at India and abroad.

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