Floor Layout Planning Using Artificial Intelligence Technique

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ABSTRACT

- In the era of e-commerce while buying furniture online the customers obviously feel the need for visual representation of the arrangement of their furniture. Even when doing interiors of the house it is difficult to just rely on assumptions about best layouts possible and professional help may become quite expensive.

- In this project, we make use of Genetic Algorithm(GA) which is an Artificial Intelligence technique to display various optimal arrangements of furniture. The basic idea behind using GA is developing an evolutionary design model.

- PeraNoto will generate different layout designs in 2D for the furniture keeping in consideration the structure of a master bedroom.

INTRODUCTION

FUNDAMENTALS

- In architecture and interior designing, a floor plan and furniture arrangement is a top-view diagram, of the relationships between rooms, spaces and other physical features at one level of a structure.
- Optimizing furniture arrangement depends on various factors, such as pair wise furniture relationships, spatial relationships with respect to the room, etc.
- Goal is to integrate the spatial relationship information into an optimization framework with a properly defined cost function quantifying the quality of the furniture arrangement.
- Difficult to have a global optimization scheme or a closed-form solution that yields a unique optimum.

OBJECTIVES

The objectives are as follows:

- To establish that Genetic Algorithm is a suitable technique for designing layout
- To discuss the mechanism of Genetic algorithm and to compare it with other placement algorithms and site the scenarios when it has proved to be more efficient
- To understand method of feature extraction for furniture placement system and various constraints that should not be violated while designing the arrangement of furniture
- To identify evaluation metrics used for performance analysis of PeraNoto

SCOPE

- PeraNoto generates multiple 2D layout designs for the furniture elements, considering the structure of a master bedroom
- Master bedroom considered to have a window and two doors of predefined sizes
- Furniture elements : Wardrobe, Bed and Table of fixed sizes
- Input elements : dimensions of room, positions of doors and window
- Input format : text format via a GUI
- Output format : 2D designs of possible arrangements for furniture elements

LITERATURE SURVEY

SR. NO	NAME OF THE PAPER	YEAR	RESEARCH PAPER DETAILS	REMARKS
1	Generic Chromosome Representation and Evaluation for Genetic Algorithms	2002	The author explores the role of chromosomes in genetic algorithms. The author explains the breakdown of the basic genetic algorithm.	The proposed system has been successfully implemented as a high-level modeling language called OPML (Optimization Problem Modeling Language) together with a general-purpose Genetic Algorithm-based runtime.
2	Feature Selection Method using Genetic Algorithm for the Classification of Small and High Dimension Data	2004	The authors propose an efficient feature selection method that finds and selects informative features from small or high dimension data thereby maximizing the efficiency of the classification process using genetic algorithm and support vector machine.	They proposed two approaches, GASVM- a combination of GA with SVM without any modification in chromosome representation and New-GASVM which will modify the model of chromosome representation. On comparing the two, New-GASVM is a better system.

SR. NO	NAME OF THE PAPER	YEAR	RESEARCH PAPER DETAILS	REMARKS
3	Space Layout Planning using an Evolutionary Approach	2006	The authors describe a design method based on constructing a genetic/ evolutionary design model whose idea is borrowed from natural genetics.	The authors propose a reordering function to get unique genotype. Also, comparison is done between processes in Liggett's Space Layout System and the EDGE system.
4	Office Layout Support System using Genetic Algorithm– Generation of Room Arrangement Plans for Polygonal Space	2010	The author has proposed the system to work using combined genetic algorithm based on GSA and AGA.	The proposed system is compared with normal genetic algorithm, AGA and GSA and it is found that the proposed system (combined genetic algorithm) gives the best results..

SR. NO	NAME OF THE PAPER	YEAR	RESEARCH PAPER DETAILS	REMARKS
5	Make it Home: Automatic Optimization of Furniture Arrangement	2011	The authors conducted a study to show that their system could synthesize multiple furniture arrangement. It discusses Furniture Relationship Extraction, Furniture Arrangement Optimization and various Constraints that should not be violated.	The authors resort to stochastic optimization methods, specifically, simulated annealing. The constraints taken into account for the proposed system are Accessibility, Visibility and Pathway Connecting Doors.
6	An evolutionary strategy enhanced with a local search technique for the space allocation problem in architecture	2013	The proposed system couples an Evolutionary Strategy (ES) with a Stochastic Hill Climbing (SHC) technique i.e. uses Evolutionary Program for Space Allocation Problem (EPSAP).	It is able to generate different candidate floor plans to be used in the early stages and then uses operators like Wall Alignment Operator and Void Remover Operator for the final output.

SR. NO	NAME OF THE PAPER	YEAR	RESEARCH PAPER DETAILS	REMARKS
7	A Genetic Algorithm approach to motion sensor placement in smart environments	2015	This paper deals with deciding the strategic location of sensors over a given restricted area. A comparison is made between efficient algorithms.	The baseline algorithms concentrate on covering more of the space rather than intelligent arrangement of the objects. The GA and Hill Climbing algorithm focus on optimal arrangement of objects around each other based on some predefined conditions. The result of comparison is that genetic algorithm gives the best results.

INFERENCES

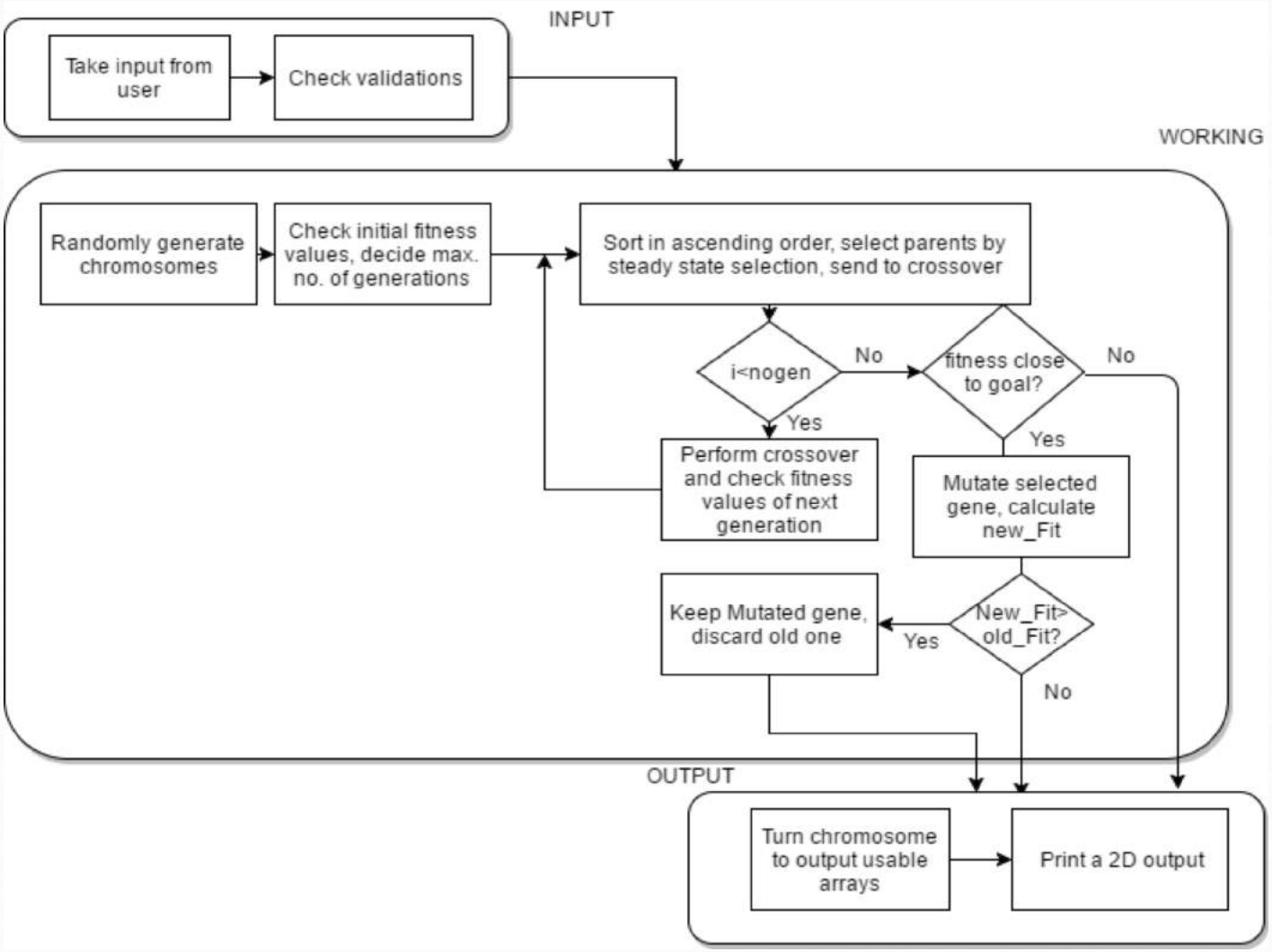
- Genetic algorithm is the best approach for our system
- Coupling of an evolutionary search technique is good especially for large-scale problems
- New-GASVM produces better result as compared to GASVM
- Combined GA can be used for similar systems
- For a highly complex search space stochastic optimization can be used

EXISTING SYSTEM: DRAWBACKS

- Chances of missing out efficient layouts due to human errors
- Compromising with output by selecting room layout from the given set of layouts
- Difficulty in visualizing the layout due to the use of furniture image that are non-scalable with respect to room dimensions
- Time consumption in thinking of layouts and designing them

PERANOTO

METHODOLOGY FLOWCHART



CHROMOSOME

- Randomized population of chromosomes is generated

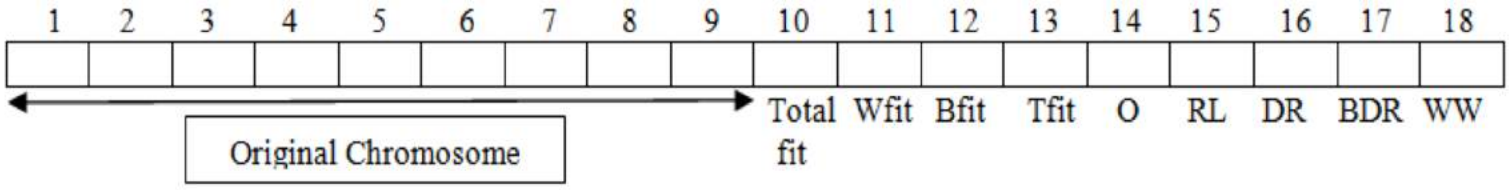
X_B	Y_B	A	X_T	Y_T	A	X_W	Y_W	A
1	2	3	4	5	6	7	8	9

- Contains information about left bottom corner and alignment
- sub- range (1:3) represents Bed ; X_B and Y_B are coordinates of the bottom left corner of the Bed
- sub-range (4:6) represents Table; X_T and Y_T are coordinates of the bottom left corner of the Table
- sub-range (7:9) represents Wardrobe; X_W and Y_W are coordinates of bottom left corner of the Wardrobe

FITNESS SCORE TABLE

Constraints	Wardrobe				Bed				Table			
	Min Score	Max Score	Flags		Min Score	Max Score	Flags		Min Score	Max Score	Flags	
			Yes	No			Yes	No			Yes	No
Overlap with Bed	0	10	1	0	-	-	-	-	-	-	-	-
Overlap with Table	0	10	1	0	0	10	1	0	-	-	-	-
Within room dimensions	0	10	1	0	0	10	1	0	0	10	1	0
In front of room door	0	10	1	0	0	10	1	0	0	10	1	0
In front of washroom door	0	10	1	0	0	10	1	0	0	10	1	0
In front of window	0	10	1	0	5	10	-	-	7	10	-	-
Near to any walls	5	10	-	-	5	10	-	-	5	10	-	-
Total Max/Min Score	5	70			10	60			12	50		

FITNESS EVALUATION

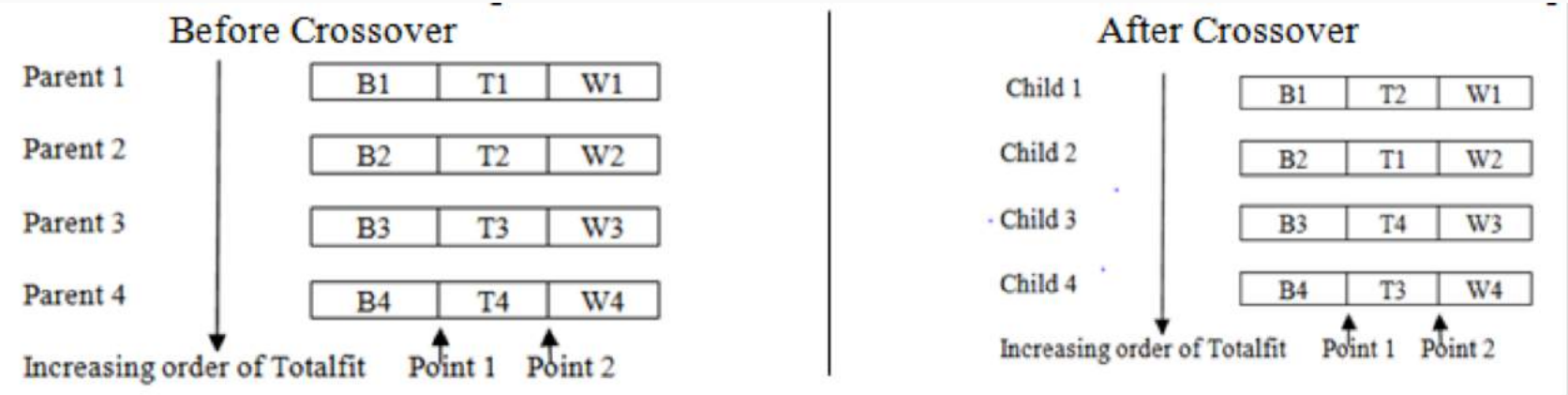


- Totalfit - Fitness value scored out of 180 for the entire chromosome
- Wfit - Fitness value scored out of 70 for the arrangement of Wardrobe
- Bfit - Fitness value scored out of 60 for the arrangement of Bed
- Tfit - Fitness value scored out of 50 for the arrangement of Table

FITNESS EVALUATION

- Flag O - Set to 1 if Overlap condition occurs
- Flag RL - Set to 1 if furniture objects exceeds room dimensions
- Flag DR - Set to 1 if furniture objects in front of room entry door
- Flag BDR - Set to 1 if furniture objects in front of bathroom door
- Flag WW - Set to 1 if Wardrobe in front of window

CROSSOVER

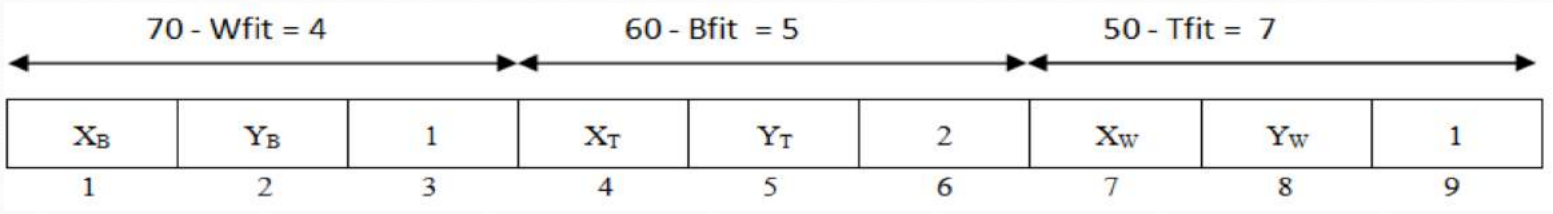


- Threshold value set for Crossover
- Chromosomes arranged in Ascending order
- 2 Point Crossover

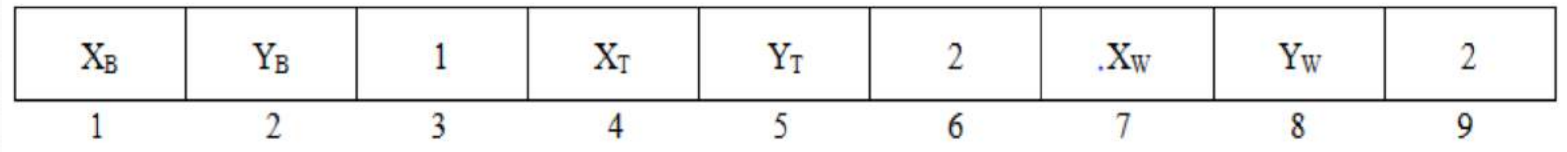
MUTATION

- Mutate when fitness value almost equals goal value
- Changes alignment of any one object
- Object Mutated =Object max (diff (goal, current))
  =Max((70-Wfit),(60-Bfit), (50-Tfit))

Before Mutation



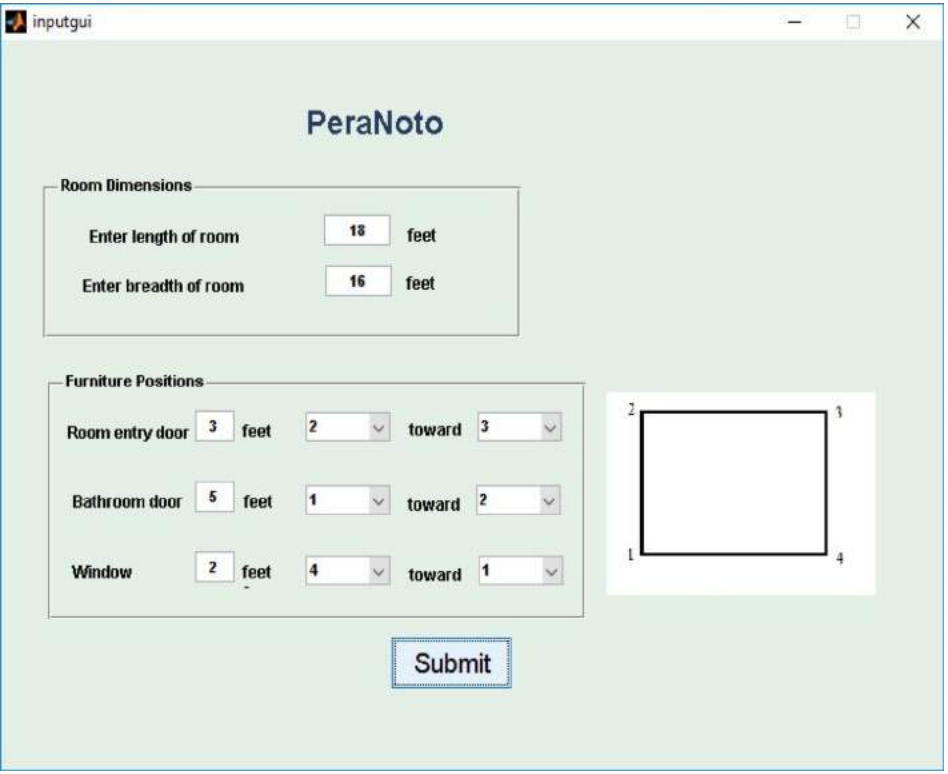
After Mutation

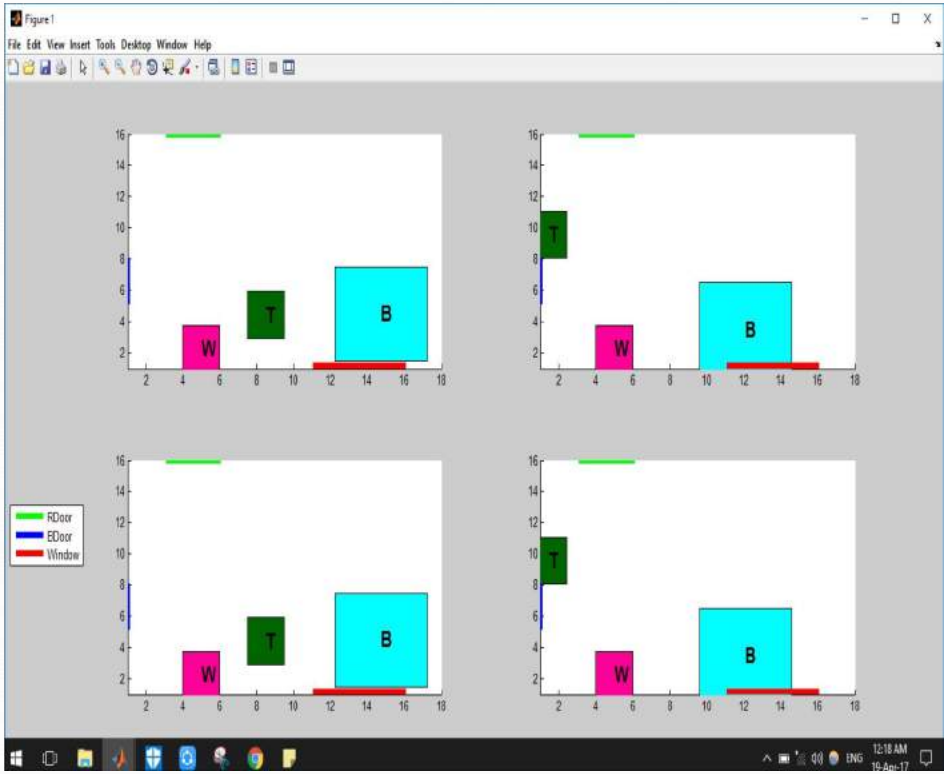


RESULT AND ANALYSIS

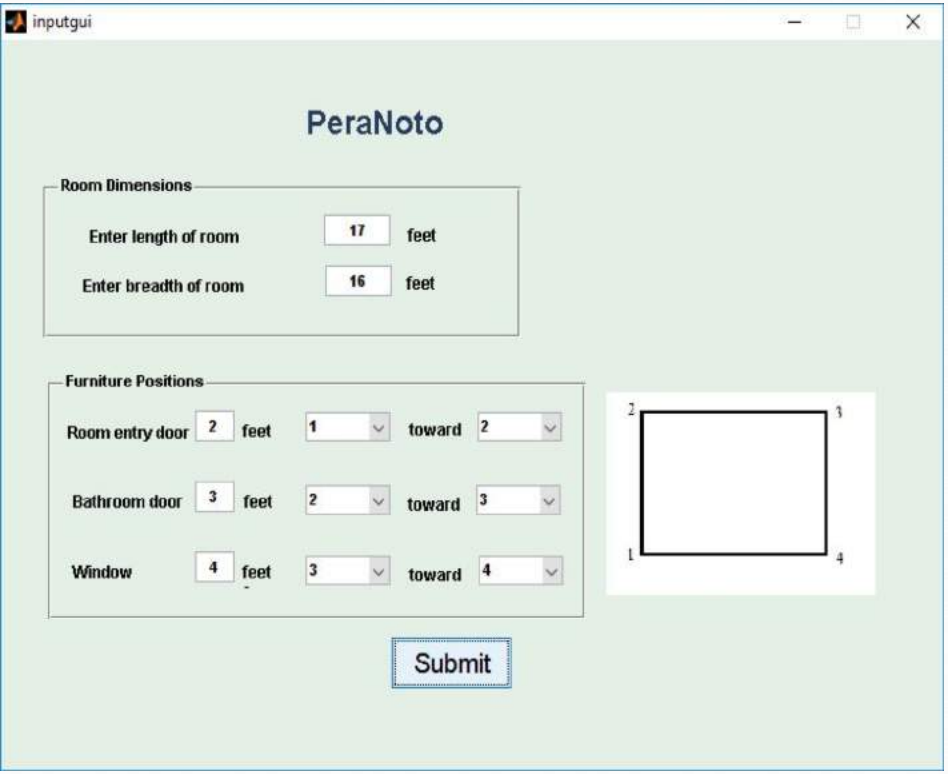
INPUT AND OUTPUT SCREENSHOTS

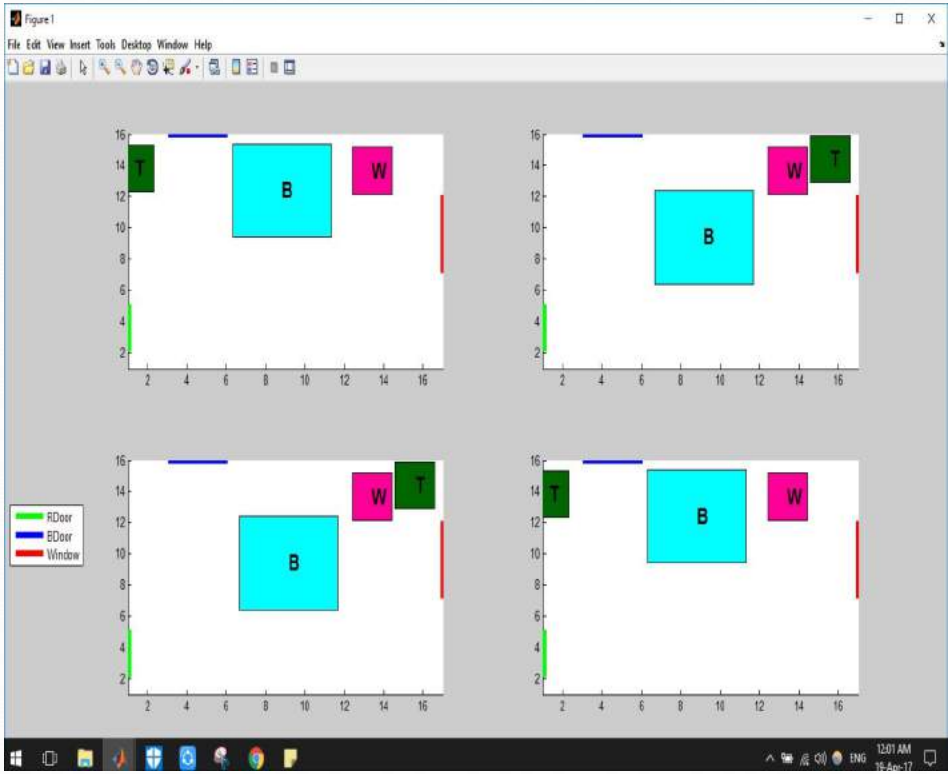
- For a room of dimensions 18x16:



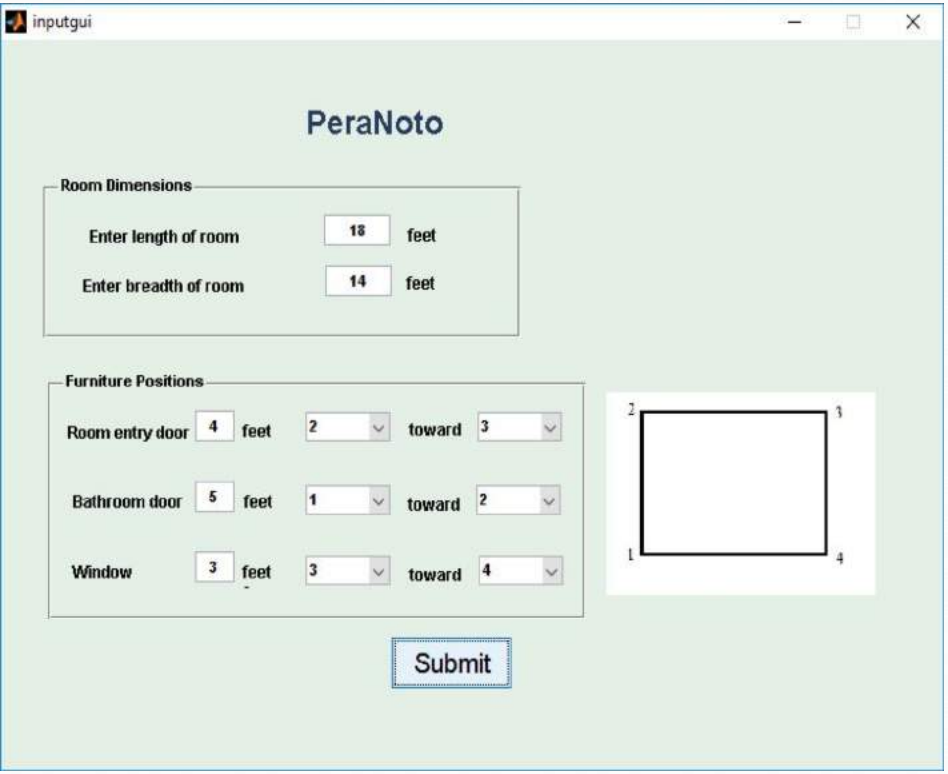


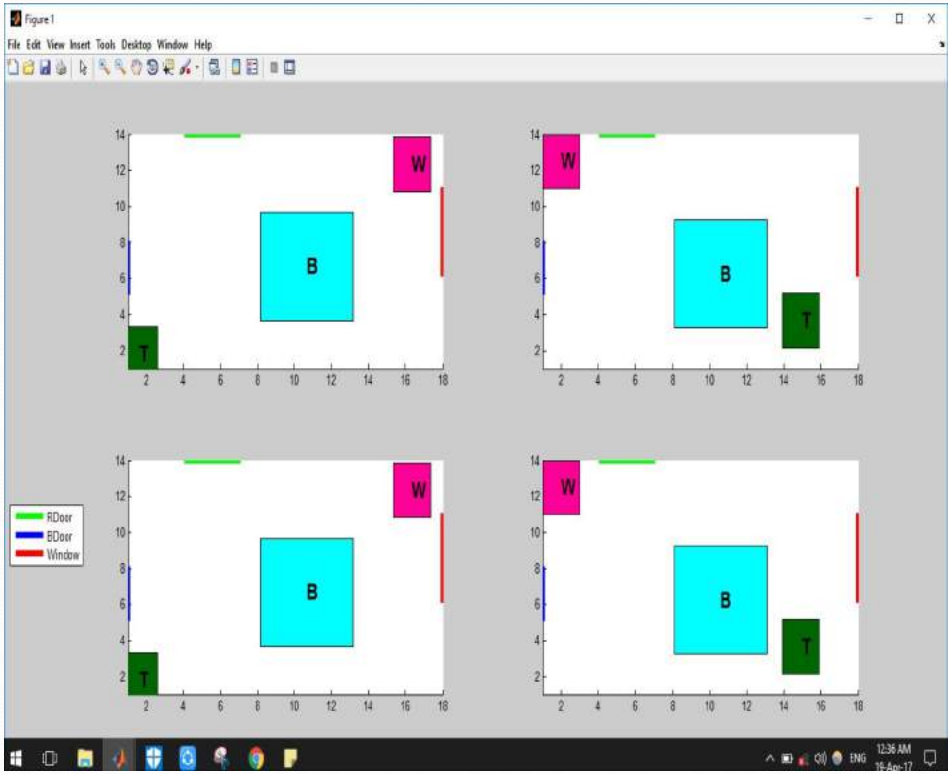
- For a room of dimensions 17x16:



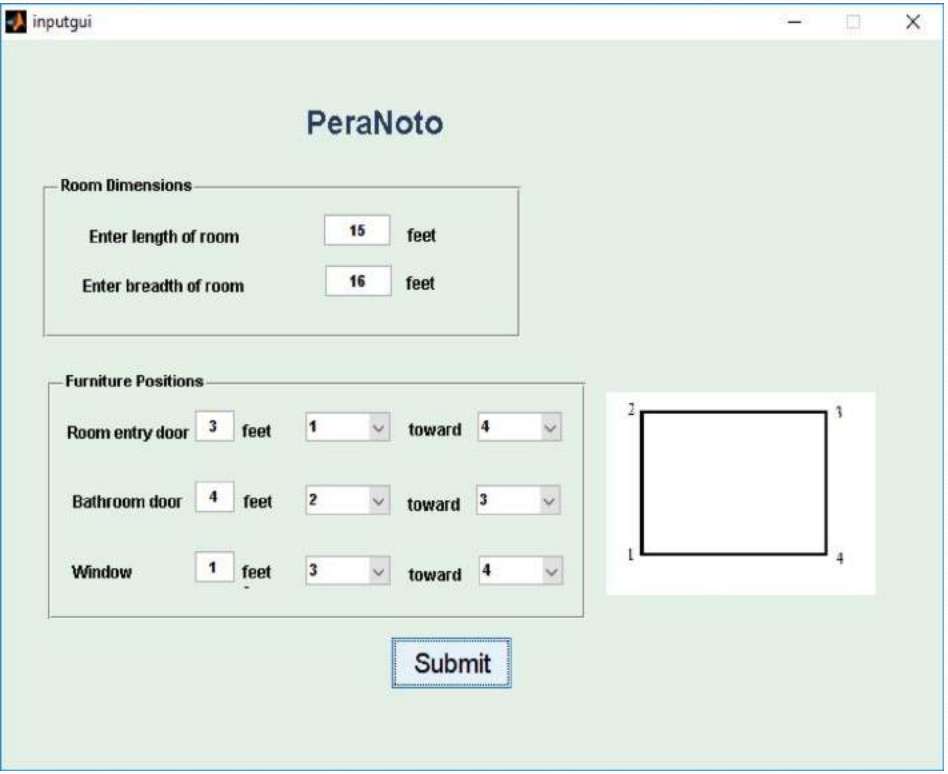


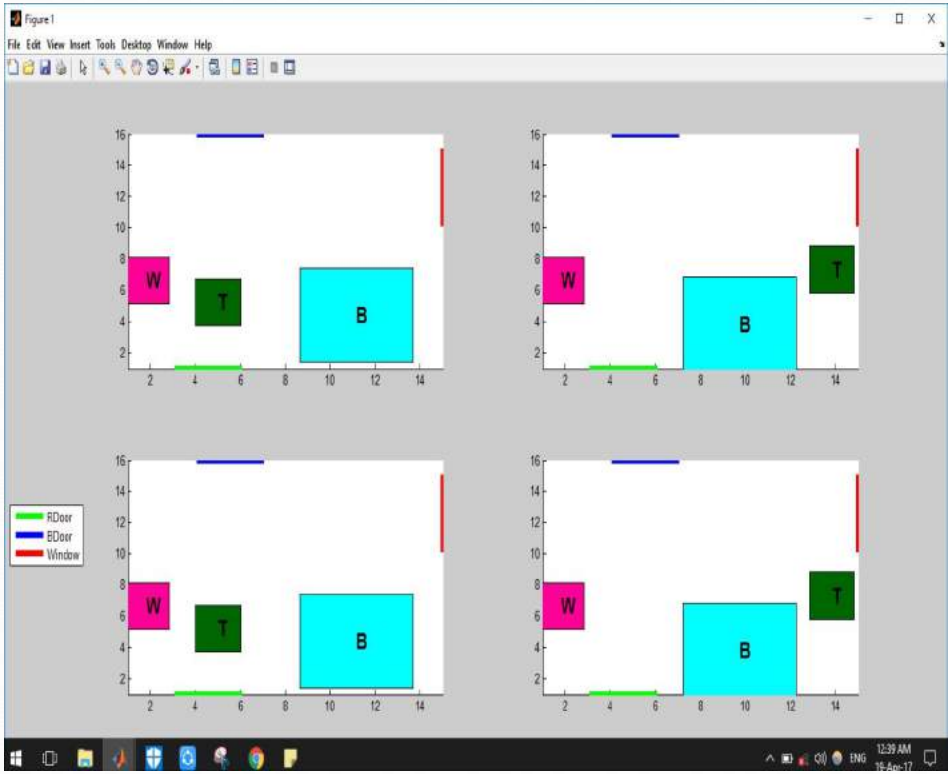
- For a room of dimensions 18x14:





- For a room of dimensions 15x16:





EVALUATION PARAMETERS

Evaluation parameters for projects include:

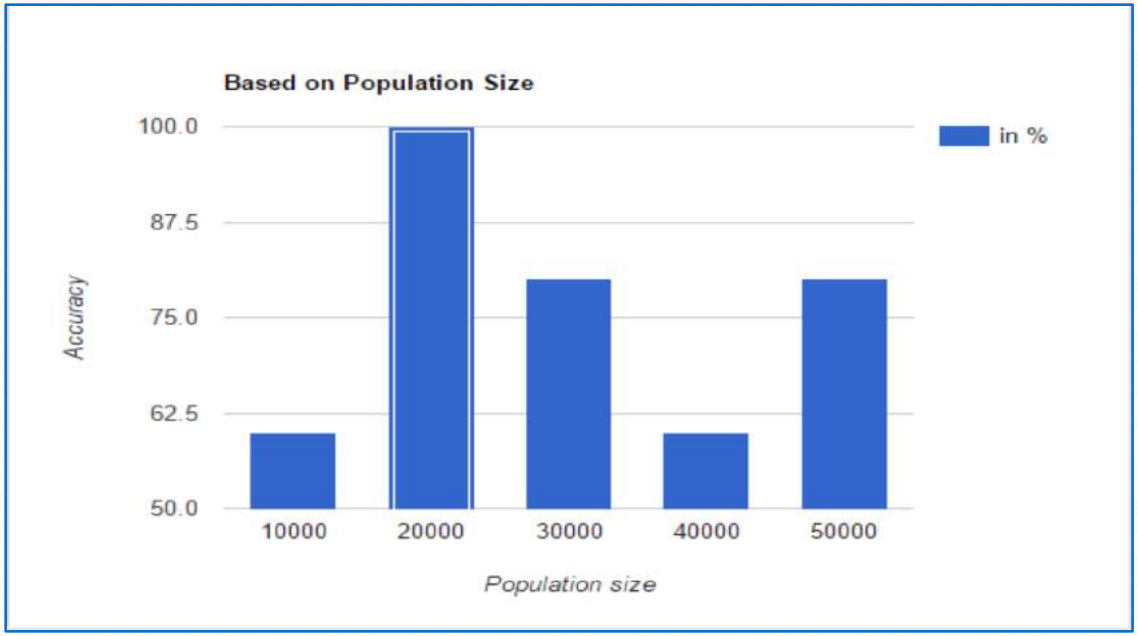
- Relevance : Assess whether the project fulfils an important function from a development perspective
- Effectiveness : Assess whether a development project has achieved its goals
- Efficiency : Assess whether project in best possible manner without the least waste of time and effort
- Accuracy : Measure of how close output values are from desired values

PERFORMANCE EVALUATION

- Relevance:
  - NP-complete problem that has not yet been implemented
  - One of its kind system
- Efficiency, effectiveness and accuracy:
  - In Genetic Algorithm analysis depends on:
    - Initial population size
    - Number of generations
  - Selection of size and number of generations depends on problem statement
  - Differs for each requirement

ACCURACY

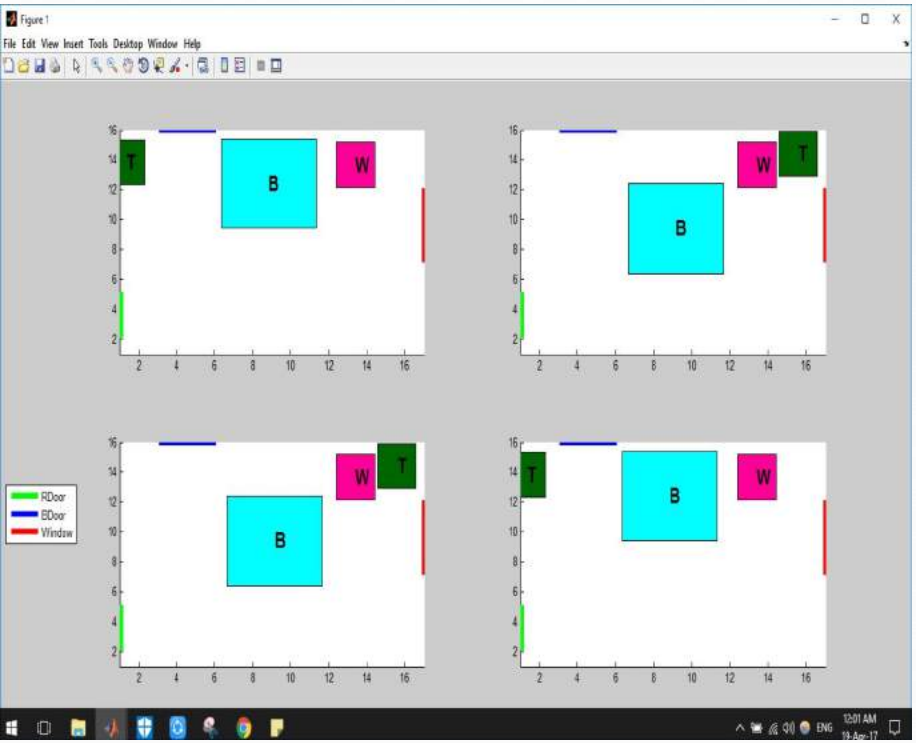
1. Accuracy Based on Initial population size

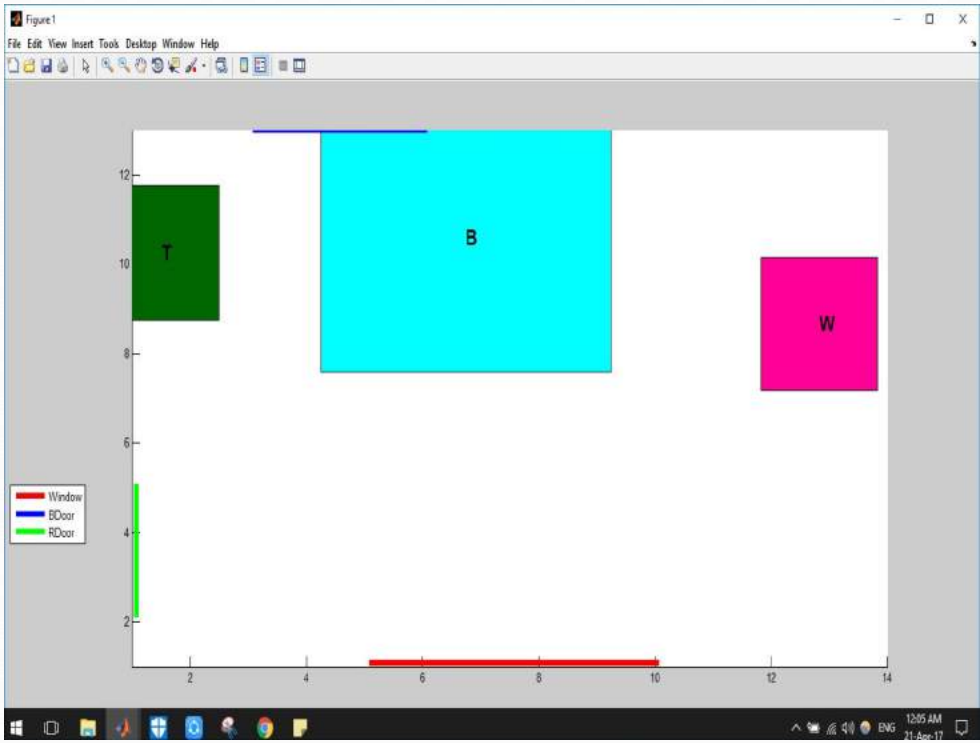


Based on above analysis, the population size was chosen to be 20,000 as the accuracy percentage obtained was best

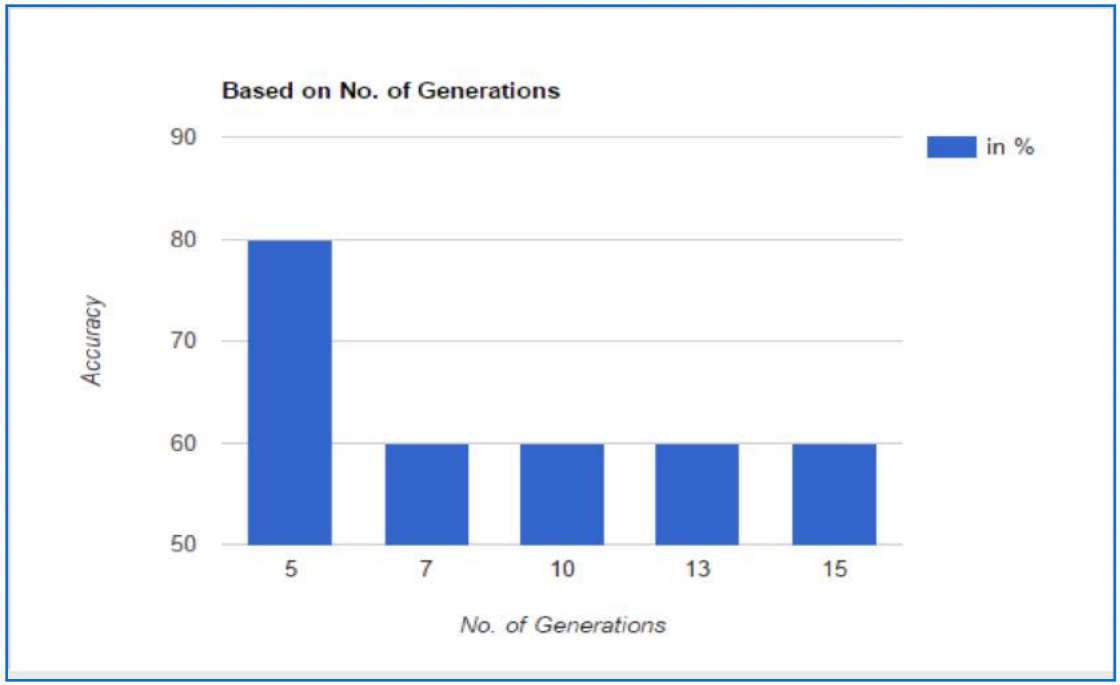
On comparing the outputs:

- For Initial population size: 20,000
- For Initial population size: Other than 20,000





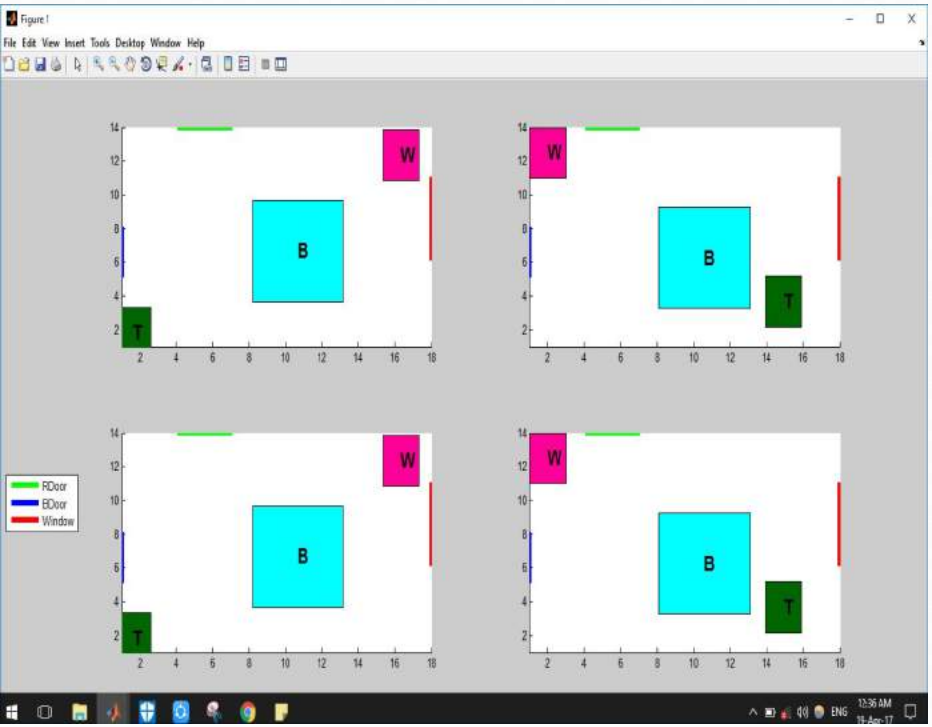
2. Accuracy Based on Number of Generations



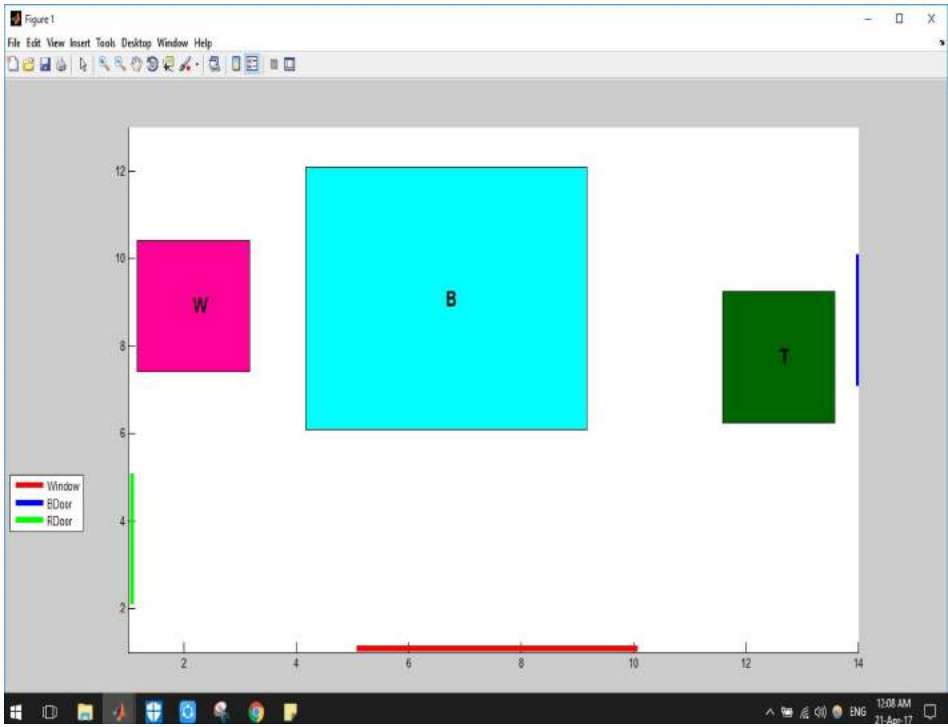
Based on above analysis, the number of generations was chosen to be 5 as the accuracy percentage obtained was best

On comparing the outputs:

- For Number of Generations: 5

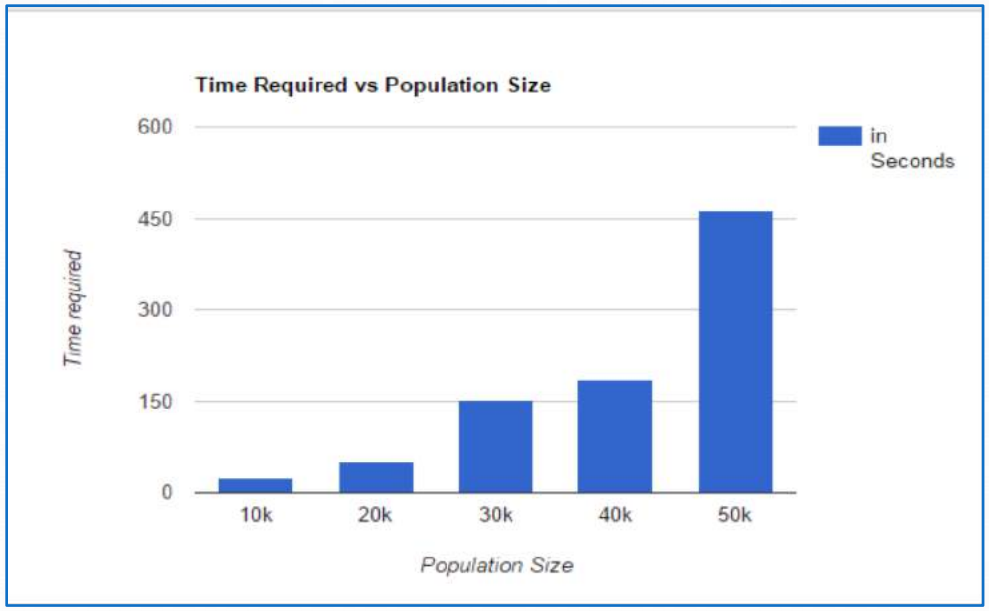


- For Number of Generations: Other than 5



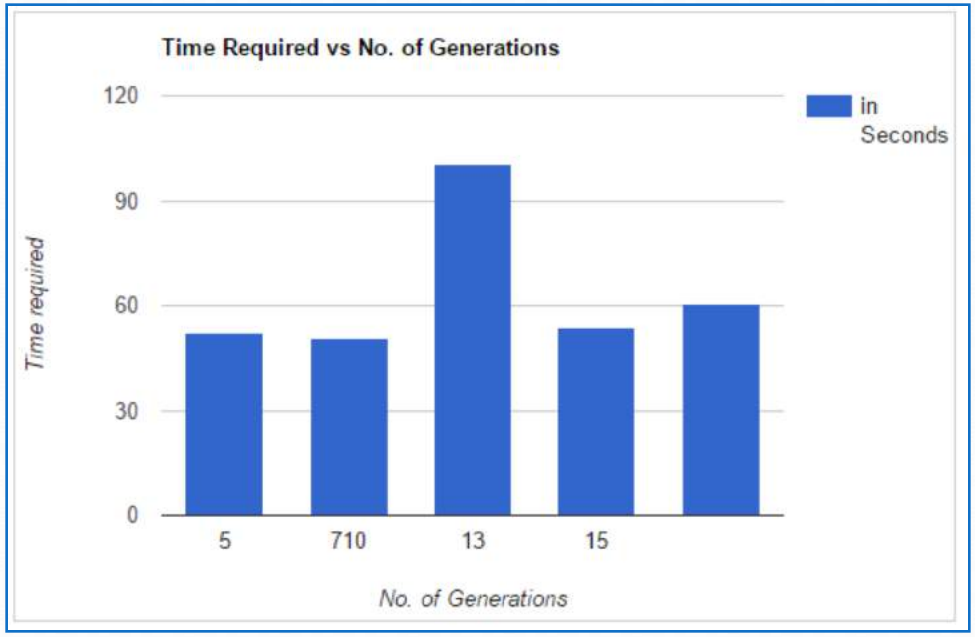
EFFICIENCY (IN TERMS OF TIME REQUIRED)

1. Time Required Based on Initial population size



- Directly proportional relation between population size and time required
- As population size increases, system requires more time to process the computations on genes

2. Time required Based on Number of Generations



- No significant relation between the number of generations and time required observed
- Affirms that time required depends on population size only

FUTURE SCOPE

- Township planning
  - Arrangement of residential buildings considering their proximity to schools, markets and hospitals
  - To plan the layouts of roads and bridges
- 3D output
  - Can be achieved using Augmented Reality
- Interior designing
  - Planning interiors of a whole office or a luxury hotel

SUMMARY

- System yields layout designs for furniture arrangements
- User inputs- dimensions of the room and the positions of the doors and window
- Genetic Algorithm – Artificial Intelligence technique
- Future Scope- township planning, interior designing, home layout planning, 3D output using augmented reality
- Planning done within a very short span of time, thereby replacing the need for the tedious work of interacting with interior designers on-site

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LIST OF PUBLICATIONS

- Research paper published in Call for Papers Volume 6, Issue 5, May 2017 of International Journal of Innovative Research in Science, Engineering and Technology

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