iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** II **Month of publication:** February 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue II, February 2018- Available at www.ijraset.com

Pathfinding using RSSI for a Fire Fighting Robot

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Abstract*: In this project, we propose navigation algorithms for outdoor environments, which permit robots to travel from one static node to another along a planned path in the sensor field, namely the Circular path finding algorithms. Using this, the robot can navigate without the help of map, GPS or extra sensor modules, only using the received signal strength indication (RSSI) and ESP. Therefore, our algorithms have the advantage of being cost-effective. In addition, a path planning algorithm to schedule mobile robots' travelling paths is presented, which focuses on signal strength for finding path by considering the RSSI-algorithm. The simulations and experiments conducted with an autonomous mobile robot show the effectiveness of the proposed algorithms in an outdoor environment.

***Keywords:* Firefighting, Robot, Software-Hardware, RSSI, Wi-Fi, Search.**

I. INTRODUCTION

First, a routing protocol must exist that can connect and pass messages in from the initial location of the robot to its final destination, by creating hot-spot using ESP-8266. Hybrid sensor networks with static and mobile nodes open a new frontier in the research into wireless sensor networks (WSN). Static nodes support environmental sensing and network communication. Mobile nodes have more resources for sensing and computing and can move to particular locations to perform more complicated missions such as rescuing the soldiers in war, rescue the people in Accidents, Exploring on others planets etc.

II. PURPOSE

With the development in the field of robotics, human intrusion has become less and robots are being widely used for safety purpose. In our day-to-day life, fire accidents have become common and sometimes may lead to hazards that make it hard for the firemen to protect human life. In such cases, a fire fighting robot is used to guard human lives, wealth, and surroundings from the fire accidents.

III. PROJECT SCOPE

The scope of our project is to design and implement firefighting robot by using software and hardware. The ultimate goal is that the ideas and planning demonstrated through this model system can then be easily upgraded. As the system is to be implemented for large dataset, there are a number of performance specifications that have to be met to ensure the system co-operates correctly and efficiently. Most importantly, The Development of two factor authentications System interface must send and receive the appropriate information at the time of sending and receiving signals getting from fire sensor. The interface in turn, must be able to multi-task and have numerous threads running at the same time in order to serve multiple users throughout the system functions. Presently we are focusing on small set of databases for demo purpose and we are using one robot and one fire sensor.

IV. LITERATURE SURVEY

The literature survey is done by us by referring some IEEE papers and some journal papers. The papers surveyed are represented in the table below.

TABLE 1 - LITERATURE SURVEY

Year	Author	Paper	Objective	Methodology
2017	Daniel Konings, Nathaniel Faulkner, Fakhrul Alam, Frazer Noble and Edmund Lai	Do RSSI values reliably map to RSS in a Localization system?	In recent years, research into localization systems has become more popular as the proliferation of (WSNs) grows. Recent work has seen systems implemented with Received Signal Strength Indication (RSSI) values from transceivers. Many algos and channel models have been presented to increase the accuracy of a RSS based system. In this paper, we experimentally check whether RSSI values map to the expected RSS values within an IEEE 802.15.4 network.	Passive localization, Signal propagation, Active tracking, Device-free localization.

2017	Maani Ghaffari Jadidi, Mitesh Patel, and Jaime Valls Miro	Gaussian Processes Online Observation Classification for RSSI-based Low-cost Indoor Positioning Systems.	In this paper, we propose a real-time classification scheme to cope with noisy Radio Signal Strength Indicator (RSSI) measurements utilized in indoor positioning systems. RSSI values are often converted to distances for position estimation.	Multi-pathing and shadowing effects, finding a unique sensor model using both parametric and nonparametric methods, Robot Operating System (ROS).
2017	Khaled A. Ghamry, Mohamed A. Kamel, and Youmin Zhang	Multiple UAVs in Forest Fire Fighting Mission Using Particle Swarm Optimization	In this paper, it is assumed that the fire spots are already detected and their co-ordinates will be sent to the fire fighting UAVs teams. Once the fire fighting team(s) receive relevant information, the team begins to solve the task assignment problem using the auction-based algorithm. The objective of the algorithm is to assign each UAV to each fire spot according to their relative distances.	Fire lookouts, Satellites, manned aerial vehicles, UAVs.
2016	Thorsten Nowak, Markus Hartmann, Tobias Zech, Jörn Thielecke	A Path Loss and Fading Model for RSSI-based Localization in Forested Areas	A prospective approach tracking tiny lightweight animals is to capture field-strength measurements utilizing a wireless sensor network. Apriori knowledge of propagation channel characteristics is essential for precise localization. Hence, in this paper a channel model for forested areas is proposed.	Path loss model, Fading, Cross Fading.
2016	Mustafa Engin	Embedded and Real Time System Design: A Case Study Fire Fighting Robot.	This paper presents the author's experiences using a low-cost microcontroller evaluation board and a commercially available real-time operating system in the laboratory component of an undergraduate embedded and real-time system design course.	Embedded and real-time systems, Encoders to get feedback.
2013	Xiuyan Zhu, Yuan Feng	RSSI-based Algorithm for Indoor Localization	With the development of wireless sensor networks and smart devices, the number of WIFI access point in these buildings is increasing, as long as a mobile smart device can detect three or three more known WIFI hotspots' positions, it would be relatively easy to realize self-localization. The paper proposes an improved RSSI-based algorithm, the experimental results show that compared with original RSSI-based localization algorithms the algorithm improves the localization accuracy and reduces the deviation.	Wireless node localization, RSSI.
2008	Charalampos Papamanthou, Franco P. Preparata, and Roberto Tamassia	Algorithms for Location Estimation Based on RSSI Sampling	In this paper, we re-examine the RSSI measurement model for location estimation and provide the first detailed formulation of the probability distribution of the position of a sensor node. We also show how to use this probabilistic model to efficiently compute a good estimation of the position of the sensor node by sampling multiple readings from the beacons and then minimizing a function with an acceptable computational effort.	RSSI, Probability distribution, Location estimation algorithm.

V. SYSTEM ARCHITECTURE

The architecture in Figure 1I shows the overall description of our system. We need a robot (i.e. a 4-wheel platform) that consists of a motor driver, 2 motors and an ESP module. We also need to install the smoke sensor at various points in the room. The sensors will be connected to the ESP module. Both the ESP modules need to be connected using Wi-Fi connection.

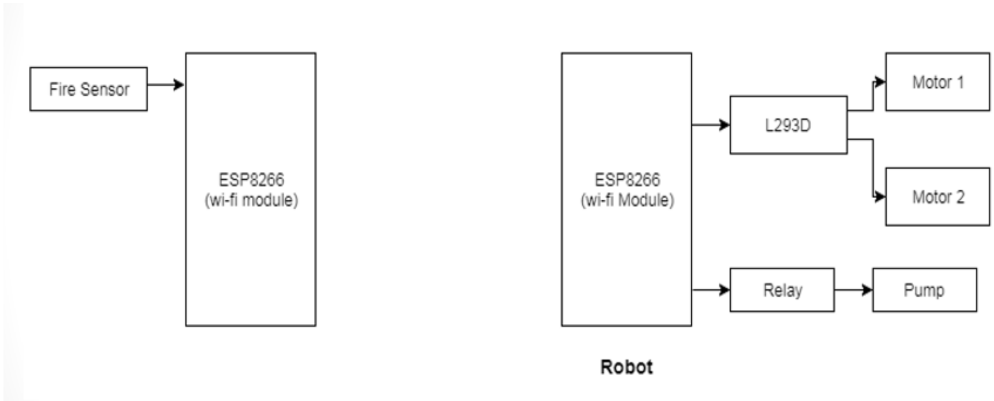

FIG. 1 SYSTEM ARCHITECTURE

VI. UML DIAGRAMS

There are a few UML diagrams that will explain our system model better.

A. Activity Diagram

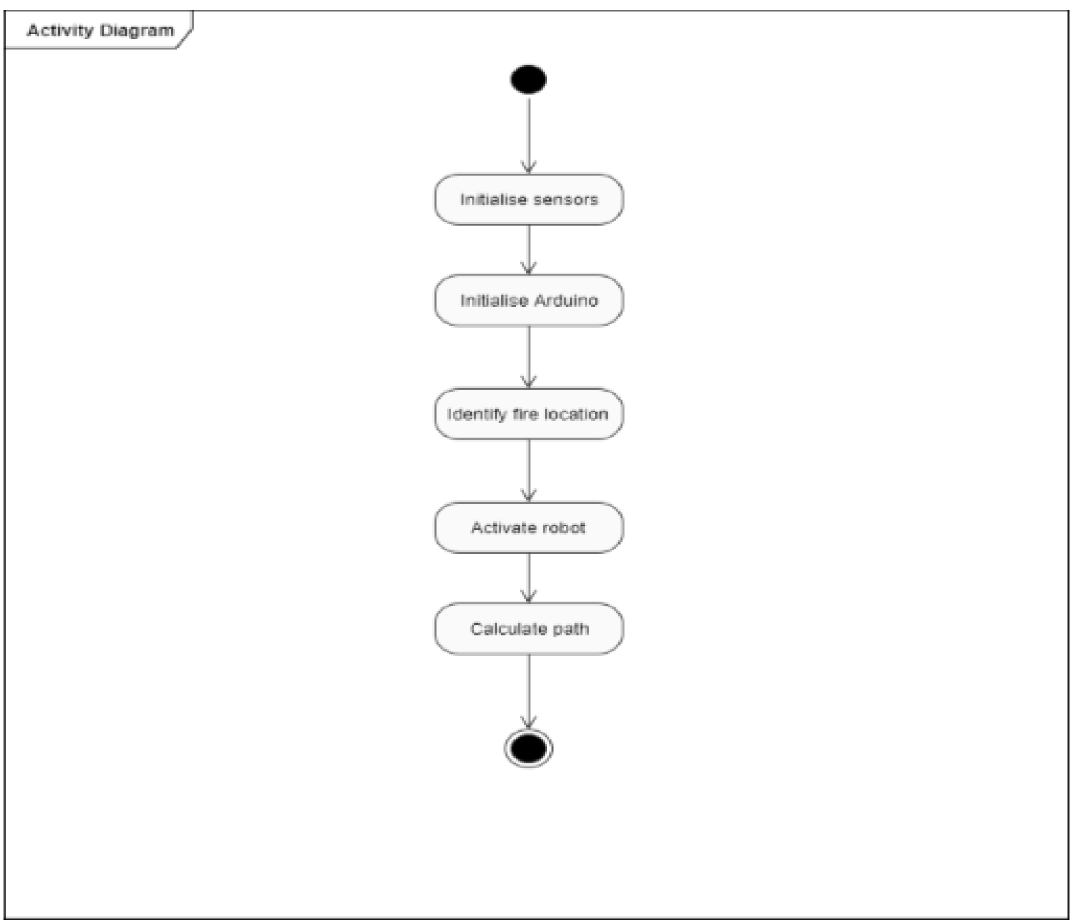

FIG. 2 ACTIVITY DIAGRAM

B. Class Diagram

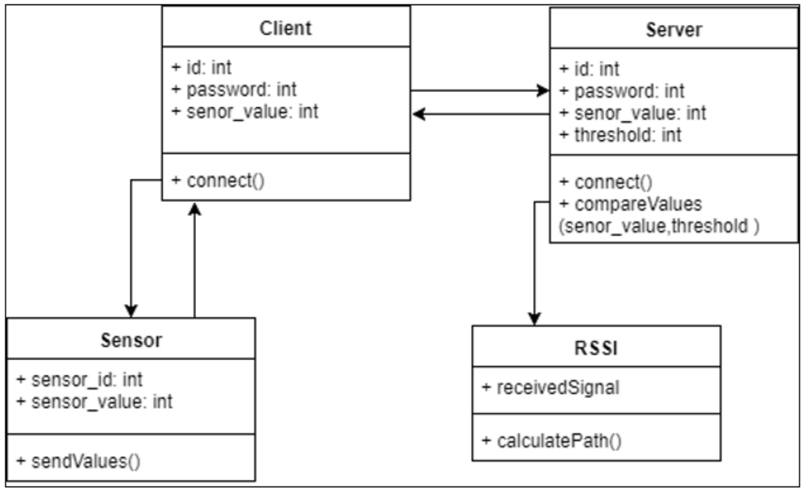

FIG. 3 CLASS DIAGRAM

C. Data Flow Level 0 diagram (DFD Level 0)

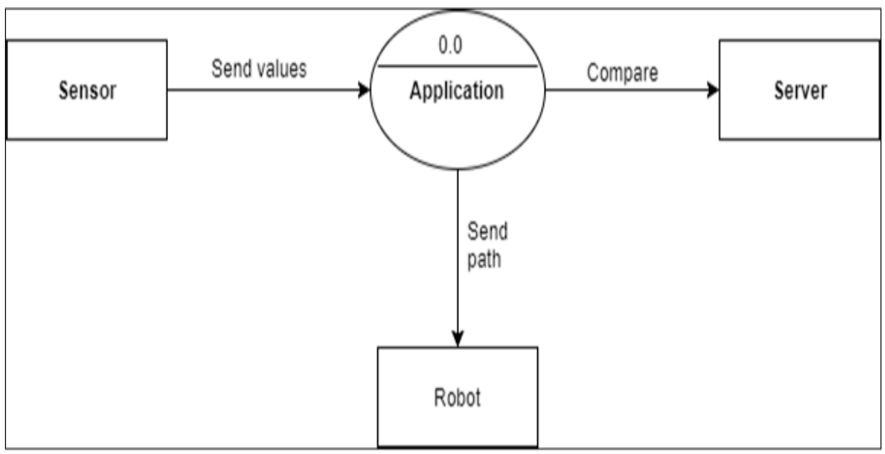

FIG. 4 DATA FLOW DIAGRAM LEVEL 0

D. Data Flow Level 1 diagram (DFD Level 1)

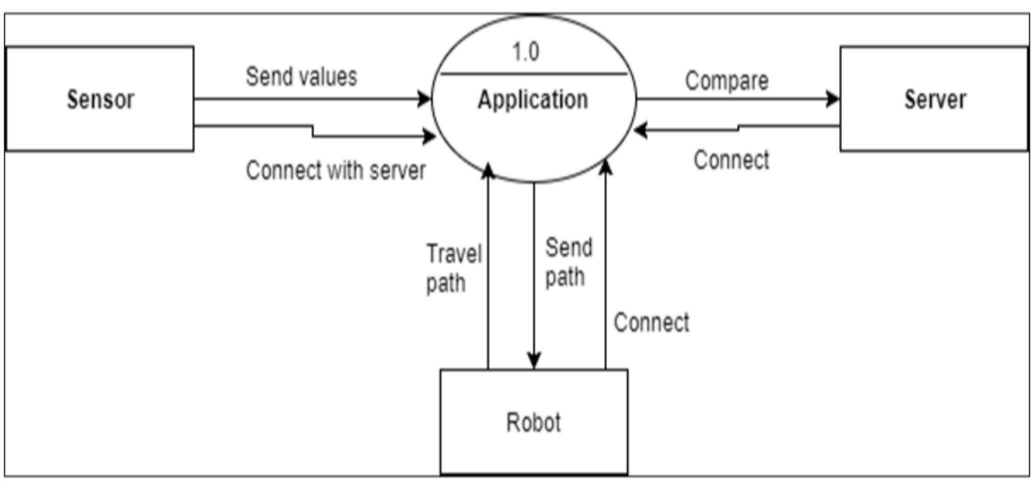

FIG. 5 DATA FLOW DIAGRAM LEVEL 1

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E. Sequence Diagram

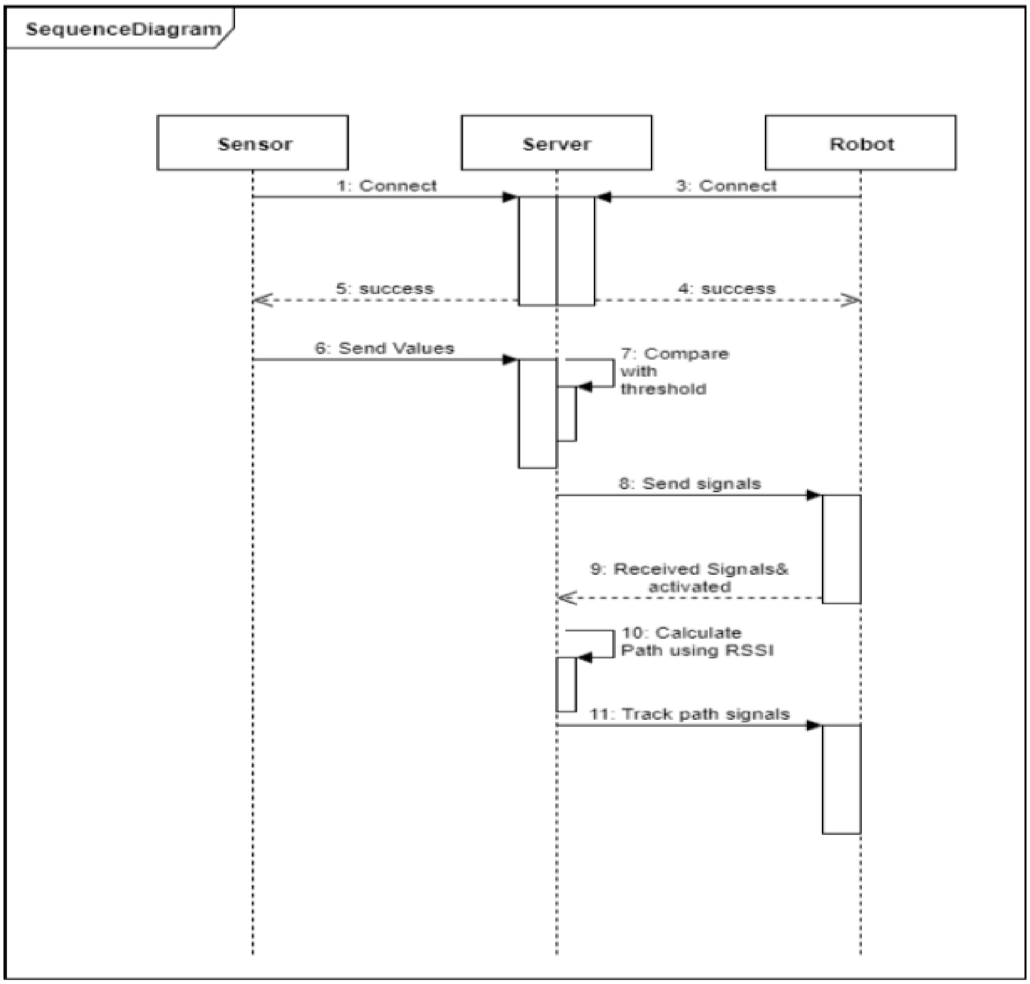


FIG. 6 SEQUENCE DIAGRAM

F. State chart Diagram

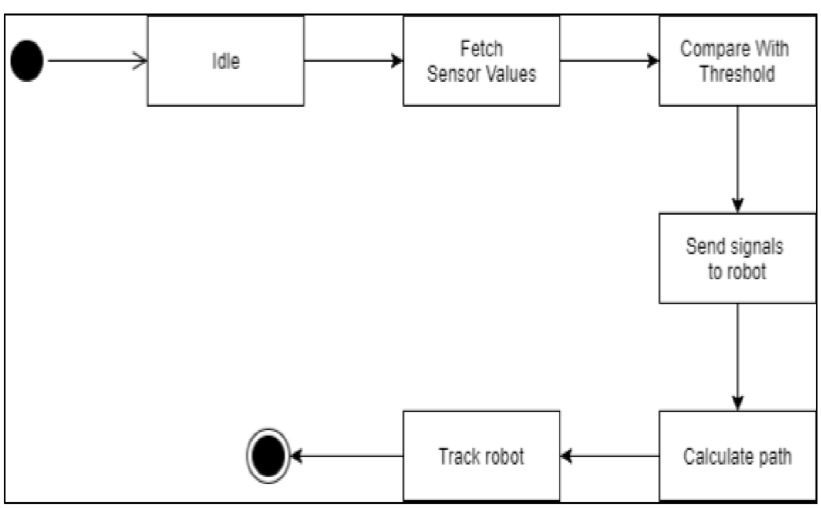


FIG. 7 STATE CHART DIAGRAM

G. Use-Case Diagram

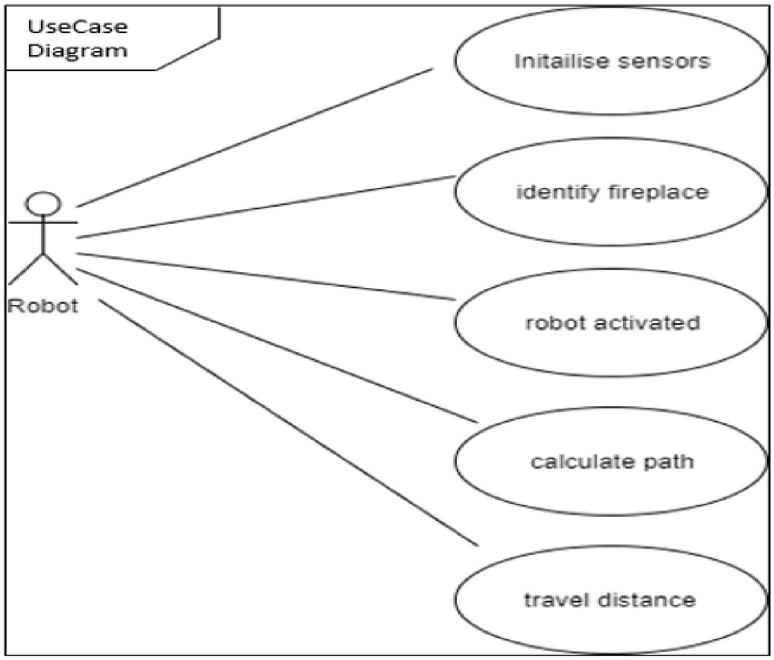


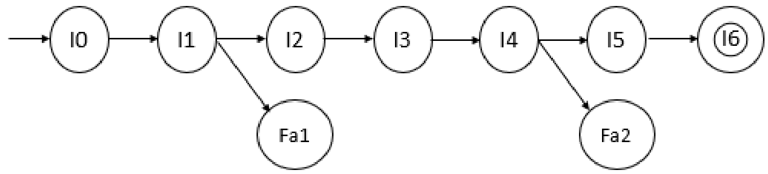
FIG. 8 USE-CASE DIAGRAM

VII. MATHEMATICAL MODEL

Let S be a closed system defined as, S = {I, O, A, DD, NDD, Su, Fa}
where,

I = Input State
= {Fire sensor value}
O = Output State
= {Path traced by RSSI}
A = Set of actions
= {F1, F2, F3, F4}
where,
F1 = Getting fire sensor value
F2 = Compare fire sensor value with threshold value
F3 = Activate robot
F4 = Calculate path using RSSI
DD = Deterministic data
= {Path found by robot using RSSI}
NDD = Non-deterministic data
= {Sensor signal}
Su = Success State
= {Su1, Su2}
where,
Su1 = {Success in getting fire sensor values correctly}
Su2 = {Success in tracing path using RSSI}
Fa = {Fa1, Fa2}
where,
Fa1 = Failed to detect fire sensor values
Fa2 = Failed to calculate path

The state transition diagram according to our mathematical model is as shown in Figure 9.



Where,

I0 = Initial State
I1 = Get fire sensor value
I2 = Compare sensor and threshold value
I3 = Activate robot
I4 = Calculate path using RSSI
I5 = Trace the path found by RSSI
I6 = End state
Fa1 = System fails to detect sensor value
Fa2 = System fails to calculate path

FIG. 9 STATE TRANSITION DIAGRAM

VIII. CONCLUSION

This robot will help in detecting fire easily and also try to extinguish it without much hassle. The ESPs installed will send a signal to the robot which will activate the robot to trace the path towards where the fire is detected. We look forward to develop this robot with the help of hardware components and software programming using Proteus and Arduino IDE.

IX. ACKNOWLEDGEMENT

First and foremost, we would like to express our gratitude to Prof. P. D. Kale, our internal guide, for her guidance and support throughout the project. Without her cooperation, it would have been extremely difficult for us to complete the project part of this semester. We would also like to thank the H.O.D. of the Computer department, Prof. D. D. Pukale, as well as the entire teaching and non-teaching staff of the Computer department for giving us an opportunity to work on such an exciting project. Last, but not the least, we are extremely grateful to our family, friends and colleagues who have supported us right from the inception of the project. Thank you for all your encouragement and support.

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