[TechBatch]

Proposal Report

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Design Studio Section:

[Section 8]

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Executive Summary

Taking precautions against disasters is of utmost importance; however, sometimes, disaster could be inevitable even if all necessary precautions are taken. In this case, the crux of the problem is effective and fast communication during search and rescue. Effective communication is the linchpin that ensures well-coordinated rescue efforts and reduces the impact of crisis. Thanks to effective and quick communication, rescue and helping resources are allocated efficiently, vital information is transmitted, and a coordinated response is given. It is this seamless and rapid communication that not only enhances the efficiency of response efforts but also significantly reduces the overall harshness of the disaster's consequences.

TechBatch presents an innovative solution: an ad hoc communication system tailored for disaster relief scenarios. This project simulates a wireless communication environment utilizing only infrared frequencies. Within this project, a rescue team is established, consisting of three mobile units and a base unit. These mobile units are equipped to locate targets swiftly and converge on disaster sites, ensuring efficient communication with the base unit for effective response coordination. In the simulation zone, we will assess real-world challenges like NLOS (Non-Line-of-Sight), LOS (Line-of-Sight), and scenarios involving multiple disaster areas individually.

TechBatch is on a mission to offer creative and eco-friendly project solutions through collaborative efforts. We're dedicated to expanding the horizons of established knowledge, promoting an adaptable learning environment, and providing practical solutions for real-world issues. By encouraging effective communication, leveraging the expertise of each team member, and continually enhancing our approach, our goal is to develop a project that not only meets academic standards but also addresses the needs of the industry. Our company is a diverse assembly of individuals with a wide range of skills. Our team includes individuals with strong educational backgrounds and expertise in signal processing, communication, electronics, and computer technology. With our strong knowledge and extensive experience, we are confident in bringing our vision to life – to innovate and implement cutting-edge solutions

This project is anticipated to conclude in six months with a budget of under $200. Its fulfillment will yield an adaptable communication system suitable for all disaster scenarios, enabling rapid and efficient search and rescue operations.

Introduction

Background of the project

In the realm of disaster relief, it is crucial to know that unforeseen difficulties and issues may occur despite preventive measures. The main challenge lies in effective communication during crises, especially during search and rescue operations. The ad hoc communication system aims to overcome the problems during disaster relief.

Problem statement

In disaster scenarios, ensuring effective communication is crucial and vital in coordinating swift and well-organized response efforts. The challenges emerge from breakdowns or inefficiencies within communication channels, hindering the exchange of vital information, and causing delays in mobilizing and organizing rescue teams. The need for reliable communication during these critical moments is fundamental. It facilitates crucial updates, enabling better coordination and optimized resource deployment. Addressing these communication challenges is key to enhancing the disaster response. By increasing the reliability and efficiency of communication systems, responders can improve their ability to coordinate actions, ensuring resources reach the most affected areas promptly. This leads to more efficient and effective disaster management, ultimately saving lives and reducing the overall impact of the crisis.

Societal impact of the project

Our initiative offers an innovative solution designed for disaster relief scenarios. It involves an ad hoc communication system with mobile and base units to swiftly locate disaster sites and perform effective communication through different areas. With the help of this project, desired communication and rescue operations can be performed in such scenarios and it may encourage people to contribute similar studies. In addition, this project can raise awareness in the society in terms of understanding the cruciality of communication in disaster relief.

Scope and organization

This proposal report will begin with an overview of the team's organizational structure. Following this, an analysis of project requirements, including functional requirements, non-functional requirements, and constraints, will be presented. The subsequent section will delve into the proposed solution procedure, outlining ideas for various subsystems. Expected deliverables will be outlined to provide a clear vision of the project's tangible outcomes. Finally, the report will conclude with the criteria for project selection, along with an appended Gantt Chart for a detailed project timeline.

Team Organization

Figure 1. Organizational Structure

TechBatch comprises five senior students from the Electrical & Electronics Engineering Department at METU. Each member specializes in different areas and holds distinct responsibilities for the project. However, despite their individual roles, all members are committed to providing mutual support in core tasks and maintaining open communication to assist one another throughout the project's duration.

Mustafa Kemal Özdemir, Chief Executive Officer, is currently enrolled in courses focusing on the computer option with a deep interest in software development and embedded systems. His previous internships provided hands-on experience in software development and embedded systems, primarily in C and C++. Kemal will join the ASELSAN team shortly to further enhance his expertise in this field. In this project, his responsibilities will predominantly revolve around the realms of embedded systems and software development.

Hasan Said Ünal, signal processing engineer, is a senior student pursuing electrical & electronics engineering, with a focus on signal processing and communication options. He possesses robust theoretical knowledge in these areas, complemented by practical experience gained through an internship at TAI and a concurrent part-time job. His involvement in Machine Learning Algorithms stems from his background as an undergraduate researcher, guided by Assistant Professor Ahmet Cemal Durgun. Furthermore, Hasan actively contributed to a computer vision team during his job at Interlabs Advanced Technologies. He will be mostly responsible for signal processing aspects of the project as well as his support for communication systems.

Tuana Merdol, electronic design engineer, is a senior student in electrical & electronics engineering, specializing in electronics and biomedical options. For two years, she contributed as an undergraduate researcher at ULTRAMEMS INC., working closely with Professor Barış Bayram, gaining valuable experience. She also completed an Erasmus Internship at Research Group Brunner in FEMTO-ST Institute, France. In this role, she was involved in implementing optical neural networks on a chip, contributing to the group's linear operations. While her primary focus lies in electronics, Tuana is concurrently exploring her interest in signal processing by currently taking a digital signal processing course. She's known for handling the electronic aspects of projects with diligence and responsibility.

Eda Özkaynar, R&D engineer, in the field of electrical & electronics engineering, is currently focusing on courses in signal processing and biomedical areas. Her expertise in these domains is enriched by diverse experiences gained from various companies.

During her internships at HAVELSAN and TUBITAK, Eda delved into object tracking algorithms, implementing them using Python. She also dedicated her studies to the development of multilateration and localization algorithms. For the past year, she has been a part of the Heart Research Laboratory, working under the guidance of Assistant Professor Yeşim Serinağaoğlu Doğrusöz. Simultaneously, she holds a position at HAVELSAN as a candidate engineer, contributing to the development of Kalman filter technology. In the current project, Eda will play a pivotal role in both algorithm implementation and development, in addition to her involvement in software development.

Mustafa Çelik, communication engineer,, specializing in signal processing and communication options within the field of electrical & electronics engineering. He demonstrates a keen interest in these areas, along with a growing passion for machine learning and AI. For the past 1.5 years, he's contributed to the REINS Research Group under the guidance of Assistant Professor Ahmed Hareedy, focusing his research on coding theory. His experience extends through internships at TAI and ASELSAN, providing him with valuable insights into software development and control theory with implementations. Presently, Mustafa is actively involved in TAI's autonomous vehicle division. In this work, he will hold responsibilities in communication systems and simulations.

Requirement Analysis

In every project and product, there are some requirements that must be met by designers because consumers expect to buy, and use completed products. Moreover, usage of some projects or products may result in vital situations such as “Ad Hoc Network Communication System for Disaster Relief” project. The project aims to design and implement an ad hoc communication system for disaster relief scenarios and consists of one base unit (BU) and three mobile units (MUs) deployed over a small area to enable search and rescue operations. If the rescue operations do not lead to success, lives of people may be lost. Therefore, requirements of this project must be met completely to avoid facing undesired results.

The project is investigated in detail and its requirements are analyzed by our company. Objectives and components of the project are determined, and there separated into two parts that are Functional and Non-Functional Requirements.

Project Objectives:

- Design a reliable and efficient communication network to be able to be used in disaster relief scenarios.
- Facilitate search and rescue efforts in scenarios such as earthquakes, fires, and floods, and improve the communication during the search and rescue process.
- Locate targets while considering obstacles and the possibility of collisions and inform the base station to call other units.

Project Components:

- Base Unit (BU): One stationary unit with a predetermined fixed location to provide communication.
- Mobile Units (MUs): Three mobile units that search the target and inform the base unit if one of them found the target.
- Infrared Communication: Communication between units is provided at infrared frequencies. Each unit needs an emitter and receiver to communicate.
- Search Area: A 2.5R x 2.5R square meter area where R is the range of infrared emitter in base unit divided into N x N tiles.
- Obstacles: Randomly located obstacles that may block line of sight communication with the BU. The information of where the obstacles are is known by mobile units.
- GUI: A graphical user interface to display real-time information known by the BU about MUs.

1. Functional Requirements:

1.1 Communication and Coordination:

- The MUs are randomly located initially.
- The BU must communicate with all MUs and coordinate their moves according to the messages it receives.
- The BU does not know where the MUs are initially.
- MUs can communicate with the BU and each other.

- The BU must receive and process location information from MUs once communication is provided and direct them.

1.2 Target Detection and Rescue:

- MUs can identify targets if they are located on or near the corresponding target tile.
- Once an MU identifies a target, it must inform the BU.
- The BU must call all other MUs to gather at the location the first MU that found the target.
- MUs should gather in the tiles next to the target.

1.3 Obstacle Handling:

- Obstacles may block line of sight communication from MUs to the BU.
- The MUs must consider obstacles when creating route to provide communication and connectivity.

1.4 Collision Avoidance:

- The MUs must form their movement path according to the information about where the obstacles are to avoid collisions with obstacles.
- The MUs must avoid collisions with each other to complete their missions.

1.5 Additional Features:

- The target may be mobile, changing its location to side tiles every 10 seconds.
- Multiple targets may be formed in the search area.
- The GUI must provide real-time information to the BU about the status and location of MUs.

2. Non-Functional Requirements:

- Reliability: The communication system must provide reliable communication and coordination to achieve detection and rescue process, especially in disaster scenarios where lives are at danger.
- Efficiency: The communication system should perform efficiently to minimize the errors in communication and required time to detection and rescue process.
- Usability: The GUI should be user-friendly and provide a clear representation of the system's status.
- Robustness: The system should handle unexpected results and errors successfully, such as collisions and connection lost.

3. Constraints:

- The communication is limited to infrared frequencies.
- The search area is 2.5R x 2.5R square meters where the range of BU emitter is R.
- The search area is NxN where N>7.
- Obstacles are one or two tiles long, with a maximum of three obstacles to block line of sight communication.
- The number of MUs is fixed at three and they are randomly located initially.
- BU does not know where the MUs are at the beginning of rescue mission.

4. Documentation:

Design specifications, technical documentation and user manuals should be provided for easier to use, maintenance and the potential developments that can be made in future.

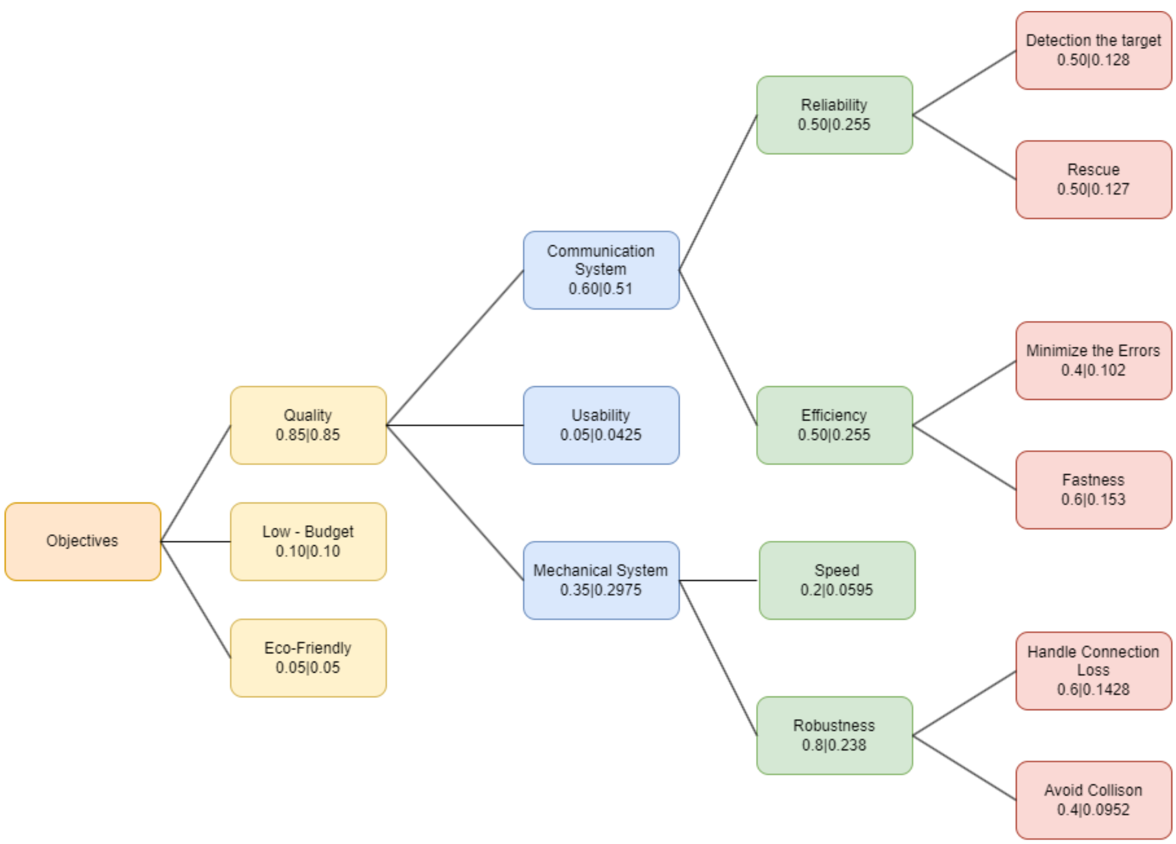

Figure 2. The Weighted Objective Tree of Ad Hoc Network Communication System for Disaster Relief

Solution Procedure

In this part of the proposal report, we plan to explain our general roadmap that we will follow throughout the project process. We break down the entire process into five components. For each of these components, we provide a detailed explanation of their expected duration, their sequence within the overall project, and their specific, well-defined purposes. This meticulous approach ensures that every aspect of the project is thoroughly understood and contributes effectively to our overarching goals.

1. Literature Review and Determining Subsystems of the Project:

Firstly we will do an exhaustive examination of existing research, publications, and relevant academic and industry sources in this part. This phase is crucial for gaining a deep understanding of the existing solutions and finding particular solutions which will satisfy our requirements. Key considerations during this phase include clear documentation of our findings from the literature review, and not approaching any solution in a biased manner since each piece of knowledge should be beneficial in the following phases.

Secondly, we will deconstruct the project into smaller, manageable subsystems. Since our project "Ad Hoc Network Communication System for Disaster Relief" contains many hardware and software systems, it is important as well as easy to separate the project. This approach allows us to create a structured framework for the project, breaking it down into logical components that can be addressed individually. During this process, we need to be careful about interdependencies between subsystems, resource allocation, and the overall consistency of subsystems with the project's requirements.

2. Testing Approach:

We consider testing as a two-part process, firstly achieving error-free system or subsystem implementation and secondly demonstrating that the system can effectively fulfill its required functionality under anticipated operating conditions. Also, testing can be divided as functional and non-functional testing. Functional testing assesses a design's ability to perform specific tasks, while non-functional testing contains tests about performance evaluation, mechanical stress and stability assessments, compliance checks, compatibility examinations, and reliability tests.

To ensure efficient project management we determine performance criteria and test directives for our project development process. The various test stages may encompass the following components:

- Measurement and Calibration Requirements and Devices: We will determine the measurements required during the project and ensure the selection of appropriate measurement equipment.
- Determining Trusted References: The establishment of a trusted reference, often referred to as 'ground truth,' is the foundation for quantifying success or failure in all tests.
- Technology and Concept Verification: The initial phase of solution development involves multiple validation steps. We will rigorously test and verify whether the design aligns with the project's requirements.
- Testing of Individual Components: Testing of each component beforehand is crucial as an unnoticed defect of one component can generate more severe problems in the overall system and may be hard to debug the root of the problem.
- Testing the Consistency of the Systems with the Requirement: The proposed systems should be tested to see if they meet functional and performance requirements. Any variation from expected analytical results should be investigated in order to determine the causes that reduce the performance.

It is important to note that these test processes may evolve in response to the development of the concept design and subsystems. A more comprehensive Testing Approach Guideline can be provided after the design is finalized, offering detailed testing procedures specific to the project's unique requirements.

3. Subsystem Assignment and Requirements Analysis Phase:

In the third phase of our project, we focus on the practical implementation of the previously determined subsystems. This phase contains very crucial steps such as assigning subsystems to group members. The approach in this is to carefully match each subsystem with the team members by considering the most relevant skills, expertise and past experiences in the respective areas. This assigning process provides that the project benefits from the strengths of individual team members. Moreover, this will enhance overall project commitment and encourage a sense of ownership and responsibility.

Once the subsystems have been assigned, we will commence a thorough research and analysis to pinpoint the specific requirements for each subsystem by the corresponding team member. It is crucial to understand in-depth about the technical, and functional prerequisites of the subsystems. Additionally, the importance of rigorous documentation to keep track of the progress shouldn't be overlooked. This will ensure that the progress will be smooth and efficient.

4. Matlab Simulation:

In this part of the project, we will demonstrate simulation in MATLAB environment. This approach will give us a possibility to test, model, and analyze the behavior and performance of our solutions to subsystems, especially the algorithm.

5. Implementation and Testing of Subsystems:

This part involves applying the chosen approaches outlined in earlier stages. This will include hands-on approaches as practical work takes the center of the progress. Simultaneously, since the subsystems will have interdependencies, team members must actively collaborate and communicate to ensure that the subsystems align smoothly. This phase requires regular meetings, feedback exchanges, and joint problem-solving.

As explained before, the testing of subsystems must be completed to ensure that the final product is freed from the complications arising from the subsystems itself. To advance in the project, clear milestones for each subsystem must be met so that integration of them can be faultless. Again, documentation remains a priority to track progress because eventually we must ensure that all actions align with the final project objectives.

Finally, this part is an action part of the project, where every team member is fully committed to bringing the defined solutions to realization, working both independently and collaboratively.

6. Integration of the Subsystems and Whole System Test:

After comprehensive individual testing and verification, in this phase the system will be integrated step by step. Required tests and functional controls will be done after integrating each new system. Interface consistency, data flow verification, and interoperability are the key factors during this process. Collaborative working of group members is required in this part, thus each member needs to be well-informed about parts other than theirs.

Collective functionality of the systems will be examined through extensive testing scenarios. Moreover, integration is an iterative process, allowing us to continuously address any emerging issues and fine-tune the subsystems.

According to our component research we determine average prices for the required components of the project and present general expected expenses in the table below. Also, we consider the possible defects and malfunction cases, thus plan to buy multiple from the particular components.

Table 1: Expected expenses and fees.

Expense	Price
Motors, Motor Drivers, ESC's	$30
Power Supply for Motors (Li-ion batteries)	$30
General Chassis Components and Circuit Components	$10
Microprocessors	$100

Expected Deliverables

At project completion, the customer will receive a comprehensive simulation kit that includes:

- A square simulation area
- One target
- One base unit (BU)
- Three mobile units (MUs)
- Portable obstacles for simulating real-world non-line-of-sight (NLOS) scenarios, easily repositioned within the simulation area.

To enhance the user experience, the package is equipped with a user-friendly Graphical User Interface (GUI). This GUI provides real-time data and insights into the activities and status of the MUs, allowing for efficient monitoring and analysis.
Setting up the simulation environment is straightforward, and to guide customers through the process, a comprehensive user manual is provided. This manual offers step-by-step instructions, ensuring that users can quickly and effectively configure the system to their specifications.

Furthermore, we stand by the reliability and quality of our product, offering a lifetime warranty to provide customers with peace of mind. This warranty reflects our confidence in the durability and performance of the system.

Conclusion

Consequently, the proposal report provides an inclusive overview of the project’s initial objectives, and our approach to overcome the problems that we may encounter. It also provides insight into the structure of the team and communicates the requirements of the project, taking into account the goals of both the manufacturer and the customer. As it is stated, the ad hoc communication system aims to overcome the problems during disaster relief. In the solution procedure section, the approach method in developing this project is discussed. Also, expected deliverables and processes of the development period are detailed.

Appendix 1

Table 2: Comparison Results for the Criteria of Project Selection.

	Future Interest	Non-Dependency of Company	Low Budget	Multiple Solutions	Individual Work	Modularity	TOTAL
Ad Hoc Network	9	10	5	8	8	10	
	3,15	0,7	0,5	1,2	1,04	2	8,59
DFV	9	5	5	4	4	4	
	3,15	0,35	0,5	0,6	0,52	0,8	5,92
UGV	8	10	2	2	4	4	
	2,8	0,7	0,2	0,3	0,52	0,8	5,32
Long Thin Hauler	6	10	4	8	6	7	
	2,1	0,7	0,4	1,2	0,78	1,4	6,58
Traffic Violation Monitoring	2	10	7	5	5	4	
	0,7	0,7	0,7	0,75	0,65	0,8	4,3
Smart Baby Monitor	2	10	4	8	8	10	
	0,7	0,7	0,4	1,2	1,04	2	6,04
0:	Not Applicable	5:	Satisfy	8:	Good	10:	Excellent
		Multiple Solutions	0,15				
		Future Interest	0,35				
		Modularity	0,2				
		Individual Work	0,13				
		Low Budget	0,1				
		Non-Dependency of Company	0,07				

Appendix 2

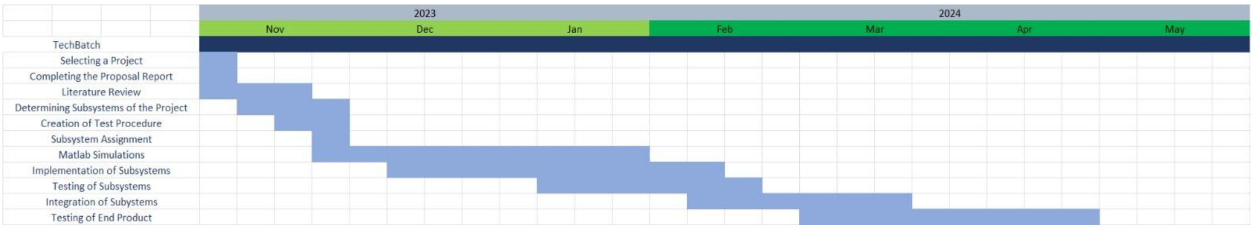

Figure 3. Gantt Chart