MIDDLE EAST TECHNICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING

PROPOSAL REPORT

EE 493

CAT FEEDING PROJECT

CEO	Ahmet Fatih Eser	2166387	0536 524 4854
Engineer	Asude Aydın	2231322	0506 051 1336
Engineer	Doğa Tolgay	2141323	0532 151 3696
Engineer	Furkan Aldemir	2247740	0535 344 5152
Engineer	Utku Serhan Suiçmez	2167187	0506 261 7500

Supervisor: Tolga Çiloğlu ciltolga@metu.edu.tr

Project's	
Starting Date:	27/10/2019
Duration:	4 months
Completion Date:	24/02/2020
Budget:	$200

Contents

1 Executive Summary

Current methods of cat feeding give way to a few problems that are promised to be solved by Felerest. The proposed autonomous smart cat feeding system, by removing these problems, makes the lives of both humans and cats easier. The system, by identifying and recognizing cats, will feed them autonomously, keeping their weight in mind. The diverse, qualified project team is confident and ready to bring this project to life. Further descriptions of the problem, solution procedure, the team qualifications, and the deliverables follow in the next paragraphs of this summary, leaving the details to the corresponding sections.

Naturally, every single cat has its own dietary habits: some cats inevitably eat more than the others. This is the reason for two of the problems of current cat feeding methods/systems: leftover cat food and obese cats. Since the proposed system recognizes cats, it is able to feed them in such a way that cats are neither hungry nor overfed afterwards; the system clearly deals with the leftover and obesity problems.

The autonomy of the system comes in to play in situations where the cat owners forget to feed their cats or have to feed them several times a day with fresh food. There is also the problem of stray dogs disturbing eating cats. This problem is anticipated to be solved by a dog deterring sub module in the system.

The project team has five members, each interested and experienced in different areas that make up this project. The various sub modules of the system are each handled by members that are experienced in that particular area. Also, the teamwork orientation of the members ensure a seamless work environment.

Felerest aims to deliver the reports, the product, the web/mobile application and a user manual for these in a time span of about four months. The research and development cost for this project will be less than $200.

2 Introduction

Are cats only a means to joy for humans, or are they rather precious companions? It is easier to answer this question after a quick reminder of a historical event: In 14^{th} century, Europe was swept over by a plague, mainly resulted by the bites of infected rats, lice and mice. People of Europe at the time were certain that this plague was God's punishment, so the 'logical' reaction was to execute Jews and alleged witches. During this manhunt, some communities also massacred village cats, thinking they were associated with witches. The removal of cats from the equation allowed a crazy amount of infected rats to continue spreading the disease, which gave way to the infamous black death. This is only one of many reasons why humans need to appreciate cats and take good care of them when necessary. Felerest, knowing that cats are not evil, believes the appreciation of human kind's precious companions should be built on solid ground.

The current autonomous cat feeding systems have only a few capabilities and are quite costly. The state of the art, according to an article on most rated automatic cat feeding systems of 2019 [1], has several key features. These are large food storage capacity, portion control settings, kibble size options and pet-proofing. This system costs 150 dollars. However, we intend to achieve all of this with extra capabilities with a maximum budget of 200 dollars. The proposed system will identify and recognize different cats and track their dietary plans. In addition to this, the proportions will be distributed with weights of the cats in mind. The system will be capable of feeding a large number of cats making it adoptable for usage in campuses and homes where cats are handful. The system's reservoir will be adequate to feed more than 20 cats for the duration of the battery lifetime, 10 hours.

There are various parameters involving a cat's appetite like its age, gender, weight, environmental factors and the brand of cat food. When the brand changes, the kcal per kg, kibble size, volume per gram also change. Therefore, the calculations were held under many assumptions and idealizations. An average cat weighing 4kg needs to consume approximately 253 kcal/day [4]. This corresponds to an average of 60 grams of dry cat food per day. For a 10 hour span the food consumption per cat is 25grams which is nearly 50ml in volume. As the reservoir volume is anticipated to be 5 liters, as many as 100 cats can be fed.

Societal marketing is one of the main concepts in the sustainable marketing environment. Companies have been developing techniques to create a sustainable world by putting some regulations into practice. Marketing has advanced such that society now has stronger impact on the market. Figure 1 shows the balance between company-customer-society where Felerest aims to create a sustainable and social environment [6].

Felerest also aims to be an environmentally friendly company that reduces trash, leftover, health risks, and energy consumption. The design allows users to easily replace broken parts by simply breaking down into sub-systems which diminishes the trash generated in repair phase and makes it impossible to impose planned obsolescence. Moreover, the regulated food drop mechanism not only provides a healthy diet that prevents cats from getting or staying overweight, but it also makes sure no food is wasted. In addition to these environmental effects, it consumes only a little power to run continuously, playing a part in reducing CO_2 emission and keeping the world sustainable. Felerest is ready to prove that it feels responsible for the environment, society, and future generations.

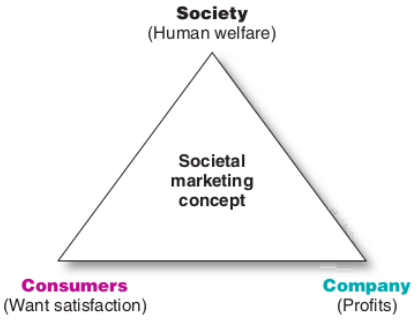

Figure 1: Three Considerations in Societal Marketing [6]

This report includes organization of the company, brief explanations about members, requirement analysis of the project, solution approaches to problems and expected deliverables of the project.

3 Team Organization

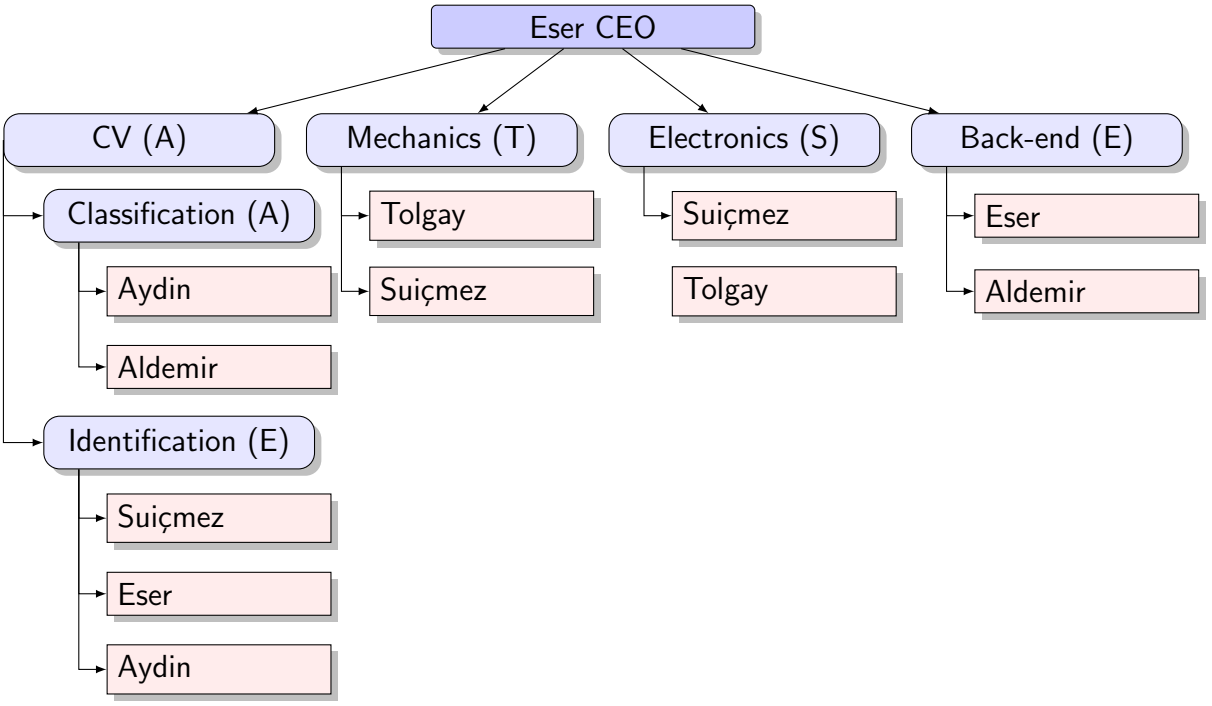

Figure 2: Organizational team structure

The members of the team have diverse backgrounds and interests; this helps come up with a clear distribution of tasks. Foci of areas differ as follows: Control and Signal Processing for Furkan, Control for Asude, Electronics and Biomedical for Utku, Electronics and a double major in physics for Doga. Doga is also a part of the Center for Solar Energy Research and Applications (GUNAM), similary Asude is in an electronics research group (ULTRAMEMS). Therefore in distributing assignments these focused areas have been taken into consideration.

The head of the company, Fatih Eser, has experiences in Business Management, Computer Engineering and the sub area of Electrical Engineering - Power Systems. Therefore, he was chosen as the Chief Executive Officer (CEO) due to his clearer understanding of the modules in the project and general background knowledge in project management.

In figure 2, the organizational structure shows the management, teams, and team members. Teams, denoted with light blue, is represented as team name and the group leader who holds the responsibility whose surname is given in parentheses. E, A, T, S letters stand for Eser, Aldemir, Tolgay, Suiçmez, respectively.

Doga has been given the responsibility to accomplish the mechanics of the projects, leading the team that deals with the construction of the cat food container, lid design, layout of the whole mechanics of the system and durability tests.

Utku will be held accountable of the electronics part of the project; he will be designing an ultrasonic dog repeller, a battery case for battery life and safety. He is also responsible for the motor of the lid system, sensors such as sonar (for detecting empty volume to estimate remaining cat food) and any extra sensors which might be added later on.

Asude and Furkan will work on computer vision problems like classification, time dependent testing, pre-processing to filter out noise and outliers, recognition via feature descriptors and any related problems that will be encountered later on. Furkan's internship experience in deep learning will prove useful in the given tasks in this module of the project.

Fatih is assigned to the software part because of his personal interests and experience in app and website development. He will be the back-end developer and will be accountable of data transfer, program optimization, interface coding and eventually development of a web based application.

4 Requirement Analysis

Objectives of the project are feeding only cats, identifying new cats and recognizing them later, deterring dogs from the area, consuming low power, as well as being cost efficient, rechargeable, portable, easy to use and robust to environmental changes. Also, feeding regime of identified cats are logged by the system. The status of the food supply and battery, profiles of the cats and feeding logs will be shared in the mobile/web application. The most important objective is the speed of the system since cats might be bored in few seconds.

Weighted objective tree can be seen in appendix A.

Requirements of the project are listed below.

- The non-removable, rechargeable Lithium-ion batteries will be completely charged from the grid in 3 hours.
- Battery will last at least five hours. The equipment will run on 18650 Lithium-ion batteries.
- There are no attachments to the animals. The animals will be identified in 4 seconds and their feeds will be automatically delivered.
- System should be lightweight in order to be easily carried by a single person. The system will be around 7 kilograms when the reservoir is full.
- To avoid food waste, each cat will be fed three to five times in a day.
- The dogs will be deterred with high frequency sounds in order not to damage them. The frequency will be around 25 to 30 kHz. However, high frequency sounds also affect cats. Solutions for this issue are being researched.
- Capacity of the reservoir will be 5 kilograms which corresponds to around 55 meals.
- Power usage will be minimized. Low current driven motor will be used.
- A light bulb will be used at nights. When the motion sensor is activated the bulb will turn on, and it will turn off in 2 minutes. This way, redundant use of electricity will be eliminated.

5 Solution Approach

Designing the solution requires passes over the problems and finding optimal solutions with minimum cost and effort. Felerest team proposes solutions that are based not only on existing problems but also potential problems in the design and implementation processes. The main objectives Felerest promises to solve are listed below, and the implementation solutions are going to be given afterwards.

There are several problems and objectives, which will then be explained in detail, such as:

1. Reliably differentiating cats and dogs from other animals,
2. Identifying the cats and determining eating habits,
3. Deterring Dogs,
4. Giving the right amount of food and water for each cat,
5. Informing the user about food and water levels,
6. Being able to work at least 5 hours,
7. Being light and movable by a regular user.

a) Recognition and Identification

Computer vision part is responsible for detecting the cats and classifying them as well as identification of the cats. Machine learning techniques and feature descriptors will be exploited to build up a powerful computation system. Neural network technologies make it easy to differentiate cats and dogs with a very high accuracy. Moreover, feature descriptors find the objects in 3D space. Also, there are several open source codes which can be used freely in this project. By looking at these codes and improving necessary parts, detecting our little friends will no longer be a problem.

b) Feeding Cats and Deterring Dogs

There is also a dog deterring system to protect the product and food from dog invasion. The deterring system will be implemented in order for dogs not to eat cat food. This deterring will be harmless. In order to achieve that, there will be a web research to determine what dogs dislike. This problem can be solved by disturbing the dogs by using a high frequency signal [3] or using a harmless spray [2] to which dogs are sensitive. For both of the solutions a controller should be designed such that when there is a threat, the deterring system should be triggered.

c) Mechanical Design

Mechanical part should be designed such that the system should adjust the necessary amount of food. This can be done by controlling the flow of the food with a door. This door must cut the food flow by the command coming from the controller. Therefore it must be a hard solid material that can move easily or rotate by a simple low power motor like a cheap servo[5]. Low power motor is preferred since it is cheaper and consumes less energy. After deciding the gate type, food mechanism should be integrated to the gate. These two parts should be perfectly matched since controlling the flow of the food is critical for this project. In every sub-step of this mechanical part, tests will be carried out with every detail in mind. Real time examples will be tested on every sub-step.

d) Back-End and Informing User

Back-end part is responsible for the software part of the project. There will be several problems after and before detecting animals: transferring video data, communication between microprocessors and server. With a user friendly approach, Felerest will develop a web/mobile application with which users can check battery and food levels.

e) Electronics Solution and Considerations

This part consists of four different tasks: dog deterring system, design of power electronics, sensor and microprocessor selection and integration, and battery selection and placement. Since our electronic devices will only work at certain voltage levels, regulators will be needed. After the selection of the electronic devices, right regulators will be selected and tested. The amount of food and water should be checked by a precise sensor, i.e. sonar or weight sensor. In order to select the right sensor a web research will be conducted and after selecting the sensor, the necessary tests will be done until requirements are fulfilled. Moreover since our design will work for five hours, a battery must be selected according to the power consumption of the circuit. By simulating the power consumption, effective battery will be selected.

f) Weight Problem

The system should be light enough for a . The design is based on an average weight around 4 kg approximately. The weight mainly due to the mass of the cat food. The other parts creating extra weight are electronic devices and mechanical parts. It is responsibility of the mechanics team to lower the mass as much as possible while preserving the functionalities. Research on material properties will be done

to lower this mass value, in both practical and theoretical way. Some trials will be done on the system since there will be unexpected results such as adding a wheel, which make the system easily movable, may cause the product to slip etc.

g) Cost Analysis

The limit for the all costs of the project is 20‘0 $. All R&D, product and manufacturing costs are included. The average expected cost is approximated as 55 $. The major cost is because of the electronic parts of the project. First suggestion is using a powerful embedded system and processing data internally. However, it became a very expensive and impractical solution since only a single processor costs 779 $ The second suggestion is based on computing on GPU server, and not to use powerful embedded system. In this approach, total cost reduces dramatically which is why we constructed our system based on cloud computing. R&G expenses are recorded as the project budget.

h) Test Plan

All parts that are going to be produced should be tested according to the correct and contemporary methods and metrics. All parts in the beginning will be tested individually which are going to be integrated after. Mechanic parts will be tested under external force for reliability which can be present in practical application. The shape change, damage ratio by looking at the shape change will be used as our metric. In addition, testing of the computer vision part will be based on real data collected from the camera during the real world application. Cats and dogs will be put in front of the product and the results will be analyzed. Accuracy will be used as the metric of the product. The communication and back-end tests will also be done based on real world application, bandwidth and accuracy of the data transfer will our measurement metrics.

i) Integration Plans

Integration plan is scheduled as below:

- Integration of mechanical parts.
- Integration of camera and microprocessor.
- Algorithm related integration on microprocessor.
- Integration of microprocessor and mechanical part.

Below you can see the detailed working areas for four groups and planned schedule can be seen as a Gantt Chart.

j) Mechanical Design

- Immediate response from controller.
- Controlling the food flow effectively.
- Integration of food mechanism.
- Making realistic tests.
- Consumption of less power.

k) Electronics Design

- Deterring the dogs without giving any harm.
- Selecting the right sensor, microprocessor and regulator.
- Calculating the overall power of the system and selecting the right battery.
- Generating a good control mechanism for the overheating and overvoltage.
- Making real time tests.

l) Computer Vision

- Making a search for features of the cats and dogs.
- Searching for open source codes.
- Improving and implementing codes.
- Testing and concluding the CV part.

m) Back-end software Framework

- Transferring video data.
- Establishing the communication between microprocessors and server.
- Designing the interface for computer camera and website.
- Building a user friendly website.
- Testing and concluding.

6 Deliverables

The products and services that will be offered are listed below.

- The box that only feeds the cats,
- A mobile/web application that will show food, water and battery level. Moreover this application will show the feeding regimes of each cat,
- Feeding diets of the various cats,
- Business Statement Report,
- Proposal Report,
- Conceptual Design Report,
- A thorough user manual for the system setup, reservoir refilling process, and the mobile/web application,
- 3-year warranty that excludes user faults,
- Charger for the battery.

7 Conclusion

This report tackles the problems of "cat feeding" and its variants such as "optimal food mass", the mass of the food that best satisfies the cat needs, "multiple cat feeding", and "efficient cat feeding".

The project explains the problem and the proposed design approach with a powerful solution. Thanks to Felerest technologies, these problems have robust solutions. Moreover, obesity in cat kind, invasion of cat habitats by feral dogs, contamination of the world by overproduction, consuming much for the environment are the key problems that the project promises to solve. As discussed before, the project develops methods for reducing food consumption and providing correct amounts of fresh food for cats.

Total cost is a considerable value; further, it is a very reasonable price when compared to the present solutions, considering additional benefits. The availability of the market and purchasing power support the business, which is why the company aims to be the leader in the future.

Consequently, the report demonstrates the long term profile, workflow, work plan, and organization of the company as well as its growth expectations. The project exhibits powerful potential, in addition to the creation of the right environment for the investors.

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Appendices

A Weighted Objective Tree

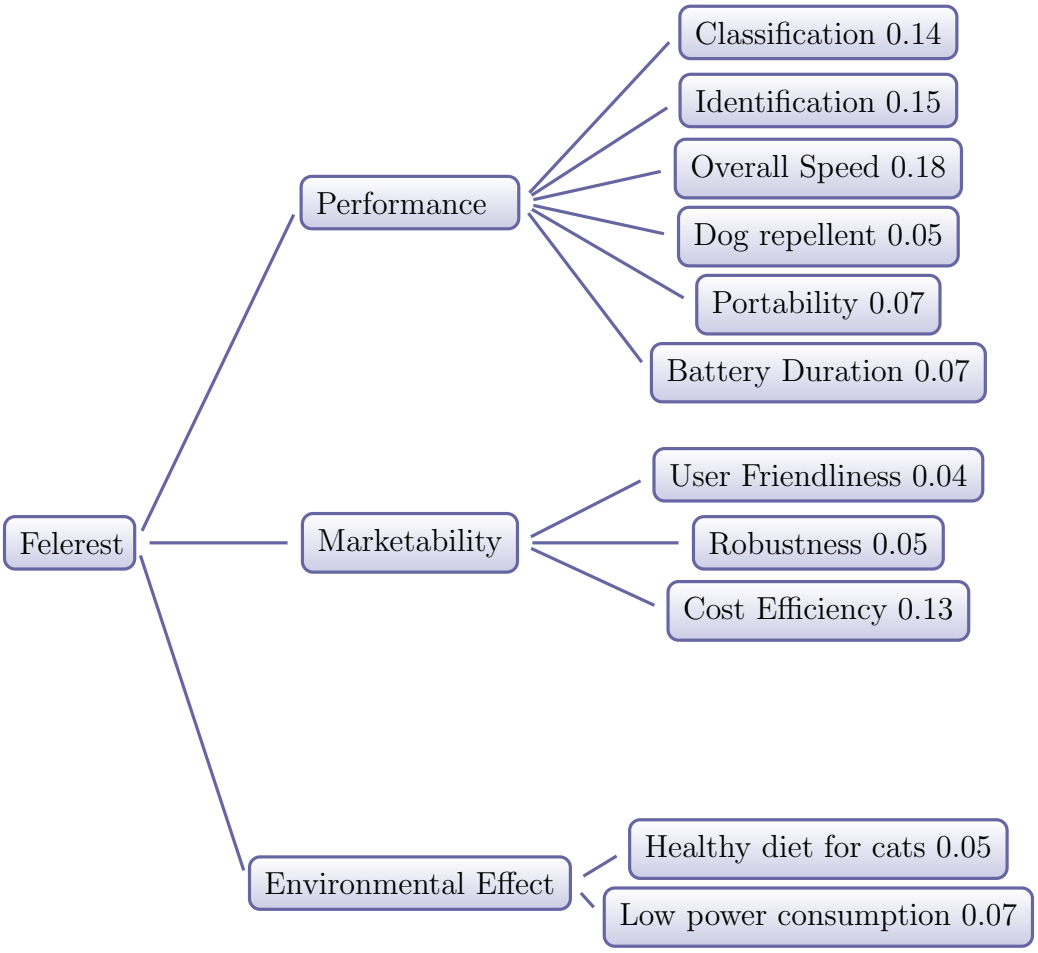

Figure 3: Weighted Objective Tree

B Gantt Chart

	Task Name
1	**Mechanical Design**
2	Cat food active / deactive
3	Gate Design
4	Gate Test
5	Case design and construction
6	Integration of food mechanism
7	Design of food framework
8	Seating of the food mechanism
9	Consolidation and error fixing
10	
11	**Electronic Design**
12	Dog deterring system
13	Research on solutions
14	Implementation of literature solutions
15	Test of the product
16	Battery selection and placement
17	Selection and testing of the possible battery choices
18	Safety and regulation adjustments
19	Integration to the system
20	Design of power electronics
21	Choice of regulators and wiring
22	Implementation and system integration of power electronics
23	Sensor and microprocessor selection and integration
24	Selecting and purchasing true sensors
25	Integrating the sensors into the microprocessor
26	
27	**Back-end software framework**
28	Transfer of the data
29	Transferring video data
30	Communicating between microprocessor and server
31	Parameter optimization and testing
32	Interface Design
33	Camera - Computer Vision Interface
34	Database - Website Interface
35	User Interface - Website Design
36	Design
37	Integration and test
38	
39	**Computer Vision**
40	Pre-processing
41	Research on pre-processing techniques
42	Implementing the pre-processing tecniques
43	Integration and testing
44	Simple Classification Problem
45	Searching for the available repositories
46	Tests of the repositories
47	Testing on the microprocessor camera data
48	Integration into the system and real-time testing
49	Identification of the cats
50	Literature search and inspection of feature descriptors (SIFT, SURF, etc.)
51	Practical implementation of feature descriptors
52	Testing of feature based identification on cats
53	Integration to the Simple Classification problem and the system
54	Advanced Methods (if needed)
55	
56	**Preparing the environment**
57	Installation of the required software to personal computers
58	Setting up of the computation server and packages