NAZARBAYEV UNIVERSITY

Capstone Project

Capstone Project Proposal

Low-cost real-time driver assistance system using Zynq hybrid SoC platform

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Project Details

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Project Summary (limit 500 words)

-What are the main objectives and aims of the project? -Describe problem statement and significance

Nowadays, traffic accident is a significant issue in a world scale, that needs to be minimized by the way of developing technologies. According to the data from “Nomad” insurance, there are about 18000 traffic accidents per year in Kazakhstan and 2500 human deaths with around 23000 serious injuries. [1] The main age category that suffers from the traffic accidents is between 17 and 29. According to the recent data from the United Nations, there are about 1.25 million deaths from the traffic accidents and up to 50 million people get injured per year.[1]

The main objective of this project is to apply developing technology to minimize the risks of accident while driving. Basically, Driver assistance, sometimes referred as advanced driver-assistance systems (ADAS), are considered as the devices that are implemented to make driving experience safer and more reliable by automating, improving or adapting some or all of the tasks involved in operating a vehicle. This project aims to explain different types of driver assistance systems both implemented in a software base and in a hardware base. Moreover, different techniques that are used in different driver assistance systems such as RADAR, LIDAR, Infrared and Video based techniques will be compared and most efficient one will be identified. [2]

In general, driver assistance system can be implemented on a software or on a hardware base. Both of these approaches will be discussed and compared, pros and cons of each approach will be identified. Afterwards, the main advantages of hybrid FPGA (Zynq) will be introduced, which is the key point of this capstone project. Hybrid FPGA is a device that includes both Processing System and the Programmable Logic. [4]

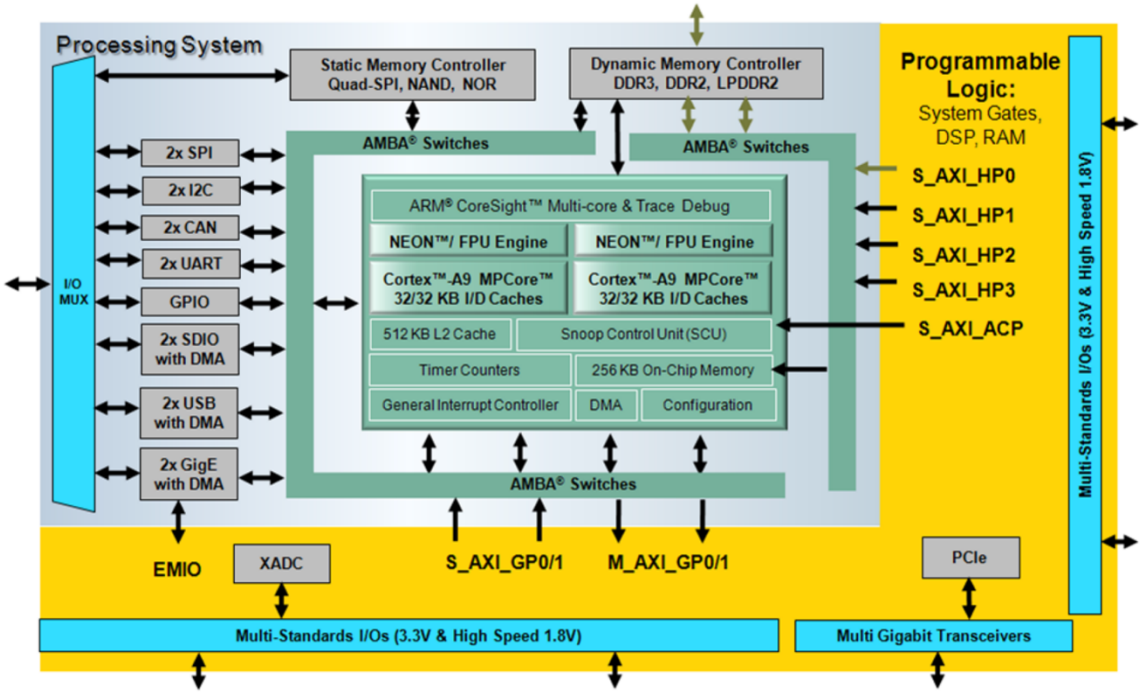

Figure 1. Internal Architecture of Zynq Hybrid FPGA.

Background (limit 5000 words)

-Significance of the problem relative to the state of the art -The problem or critical issue which the proposal seeks to resolve -How does the project meet the national priorities? -What is the potential impact of the project? -Explain the need for this project

As it was mentioned before, the number of traffic accidents is crucial and needs an attention. This number can be significantly reduced by the implementation of the proper real-time driving assistance system. Reduced number of traffic accidents is very beneficial not only in terms of safety for the drivers but for the government as well. However, diversity of these driver assistance systems leaves a question behind: What is the most efficient and reliable technique to implement driver assistance system?

First of all, it is important to note that there are many types of assistance systems such as parking assistance, lane detection, pedestrian detection, auto pilot and much more. However, it is important to note that auto pilot systems, or also referred as complete automation system, have a lot of drawbacks that could cause detrimental effects. Some of them are listed and explained below:

1) It is costly and not many people will be able to afford it.

2) The road system and infrastructure will need significant upgrades for vehicles with auto pilot system to operate on them. It is an additional expense.

3) This system can be used in inappropriate and illegal purposes such as terrorism itself.
4) Human behavior including heavy foot traffic, jaywalkers, and hand signals are really hard for a computer to analyze.
5) In case of accidents or crimes how would police resolve the issue. Should it blame a car or a driver? [3]

So, rather than having a full automation system, it is reliable to have a separate assistance system, such as lane detection, pedestrian detection and etc., that are intended to assist drivers not to replace drivers.

Another point of discussion is a diversity of techniques that are used to implement driver assistance system. These are: Radar, Lidar, Infrared, Video-based techniques and etc. One of the main objectives of this work is to find out the most efficient technique to implement. Each of these techniques will be analyzed below:

- From the time radio waves were introduced and their characteristics to reflect on objects were discovered, engineers try to find out innovative applications based on their detection and ranging properties. RADAR, also referred as Radio Detection and Ranging, works on the principle of a source transmitting the radio wave, being reflected back by a surface, received and processed by a receiver system. Basically, RADAR based driver assistance systems work on the principal of radio waves that are reflected from the objects. However, this technique has a lot of significant drawbacks. First of all, Radar based systems do not work properly in a closed environment such as tunnels. Moreover, interference of the waves from other radar systems can cause accuracy problems. Finally, it is very hard to detect small objects with radar for a relatively short wavelength value.
- Lidar is a technique which is also used in driver assistance systems nowadays. This method is similar to radar technique to some extent. However, instead of using the radio waves, lidar works on the principle of pulsed laser light. Lidar stands for light detection and ranging. Laser is bounced off from the surface at an extremely high speed: millions of pulses of laser per second. Lidar measures the time taken to reflect off the surface and generates the precise, 3D image of the object. However, Lidar is significantly expensive than Radar. In addition, Lidar systems have more moving parts which will create more room for error than Radar. Another drawback of this system is that it cannot see objects that are relatively far away and consequently have a higher risk of accident than Radar.
- Another option to implement driver assistance system is based on the infrared ray characteristics. One of the main advantages of this technique is that it shows very efficient performance in low light conditions. However, it is extremely expensive to implement it in a car.
- Video based driver assistance system is the most efficient and the cheapest technique to get a reliable driver assistance system. The working principle is based on the image sequence analysis that are taken by the camera. Moreover, this approach is very simple compared to the approaches discussed before like Radar, Lidar, Infrared techniques.[7] Techniques that are based on the wave propagation and reflection could be risky when there is an obstacle which could

block these waves. However, in case of video-based approach, this could not bring any risk as the main point in video-based approach is the image analysis.[8]

Video based approach was the most efficient one than all other techniques. However, this approach can be achieved by pure software basis or also on a hardware basis. In video-based driver assistance systems, speed of frames that are processed, that is the speed of object detection, by the device is an important factor and needs to be as fast as possible. Secondly, device has to consume as small power as possible. These two features can be achieved at the same time by the hardware approach in video-based driver assistance system. [3]

However, one of the main disadvantages of traditional hardware approach is that for every feature of the device, such as lane detection, pedestrian detection, parking assistance and etc., different hardware has to be dedicated. This is an extra expense. However, this inflexibility can be resolved by the use of hybrid FPGA. Hybrid FPGA allows us to implement several assistance systems on a single hardware. The main objective of this project is to use hybrid FPGA to implement a driver assistance system. According to the figure 1, it can be clearly seen that hybrid FPGA consists of processing system and the programmable logic. Zynq All Programmable System on Chip allows us to control software part for controlling purposes and the FPGA part for acceleration purposes. [4]

Objectives

Development objectives (limit 1000 words)

This section should describe the way in project objectives are addressed in national development strategies and policies, in terms of specific programmes and how the proposed project will relate to these strategies and policies.

The discussion should indicate the specific national social and economic objectives to which the proposal, if successful, is expected to contribute, and how this is expected to contribute to improved well being and livelihood of the project beneficiaries and the larger community.

Human safety is an important issue for every country. According to the data, which was stated before, it is fair to state that drivers are under a huge risk while they are driving. According to the data provided by the “Nomad” insurance company in Kazakhstan, probability of a traffic accident in Kazakhstan is 11 times the probability of an accident in Norway. It implies that Kazakhstan needs a proper way to minimize this number. One significant problem of a traffic accident is that lots of families lose their breadwinners. This is because the majority of victims of traffic accidents are men. Government has to support these families, and this is an additional expense for the government due to traffic accidents. Implementation of the proper driving assistance system will have a huge advantage for the government as well. [1]

According to the recent research, traffic accidents cost the U.S. $230.6 billion every year, which is an average of $820 per person. Moreover, the expenses from the fact that people could take time away from work is not considered here. So, the main development objective of this project is to minimize the expense of the government that are spent for transport purposes and accidents.

Immediate objectives (limit 1000 words)

This section should describe what the project is expected to achieve in terms of effects among intended beneficiaries. Specifically, the section discusses what changes are expected to occur among intended beneficiaries if project operations are successful. Changes can include new and improved technical skills and knowledge, increased income-generating capacities, and greater public awareness at the community, national, regional or international levels. The section should also discuss whether project operations will be extended to other future projects, as well as whether the experience can be applied to other sectors.

Immediate objective of the project is to get a general knowledge regarding the different techniques of driver assistance system. Afterwards, it is important to find out the most efficient and reliable method. According to the figure 1, the internal architecture of Hybrid Zynq FPGA is quite different than traditional FPGA, so one of the main immediate objectives is to analyze the Hybrid FPGA itself. Before writing the hardware description of the device, first lane detection and pedestrian detection techniques should be written in Python. Afterwards, the same logic of lane and pedestrian detection will be applied to create a hardware module of these features. Finally, we are aiming to get a driver assistance system which has a proper working features and is more efficient and reliable than other devices.

If project operations are successful, number of traffic accidents are expected to decrease significantly, cutting down government expenses on traffic accidents issues which were stated before.

Project implementation and plan

Capstone 1 Expected project results (limit 1000 words)

This section should describe the overall results that the project is expected to accomplish and whether there may be unintended effects of the project, and how these possible challenges will be addressed. The discussion should indicate in quantitative terms, to the extent possible, what the project will produce through its planned activities and budget.

During the first Capstone project, we will complete a literature regarding driver assistance systems, learn different techniques of driver assistance systems: compare

them. Afterwards, software implementation of the lane detection system will be performed in Python. Afterwards, hardware module of lane detection system will be implemented. After having done the simulation of this module, it will be tested on a board. Performance will be recorded and compared with the other techniques of driver assistance systems that were stated before.

Capstone 1 Project activities and work plan **(limit 2000 words)**

This section should describe how each immediate project objective will be carried out in terms of planned activities, their timing and duration, and who will be responsible for each activity. This can be summarized in a simple table.

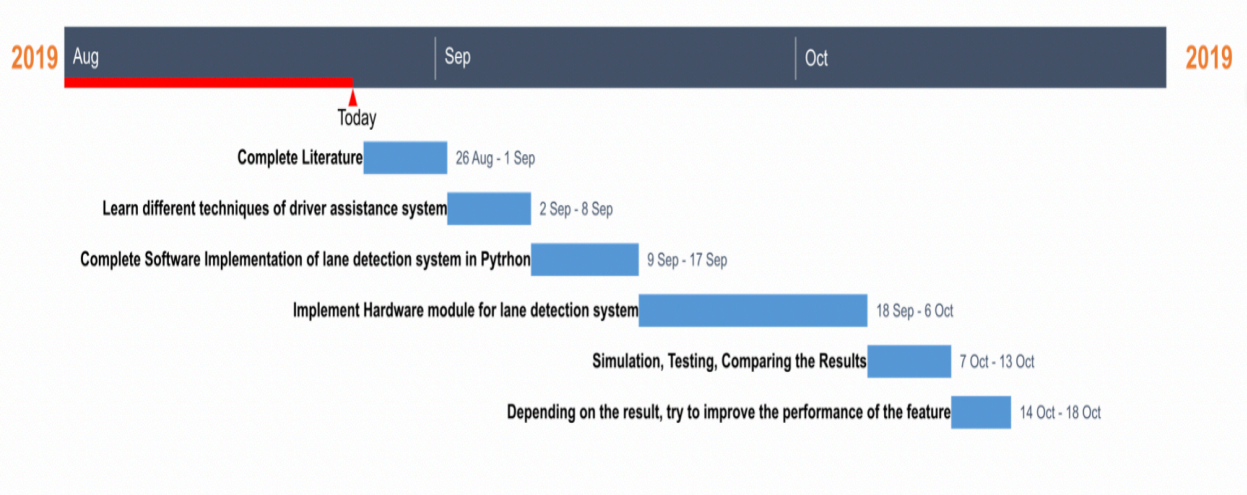

Figure 2. Gantt Chart for the Capstone 1 Project

Capstone 2 Expected project results **(limit 1000 words)**

This section should describe the overall results that the project is expected to accomplish and whether there may be unintended effects of the project, and how these possible challenges will be addressed. The discussion should indicate in quantitative terms, to the extent possible, what the project will produce through its planned activities and budget.

During the second part of the Capstone project, we are planning to implement a code for pedestrian detection in Python first. After successful completion, hardware module of the pedestrian detection feature will be performed. Afterwards, two features, which are lane detection and pedestrian detection will be combined and simulated. Software part of the device will be made in order to control the device by means of software. Performance of the device will be recorded and compared with the other driver assistance systems. In case of error detection, module will be rewritten. Finally, device will be checked on real-world case.

Capstone 2 Project activities and work plan **(limit 2000 words)**

This section should describe how each immediate project objective will be carried out in terms of planned activities, their timing and duration, and who will be responsible for each activity. This can be summarized in a simple table.

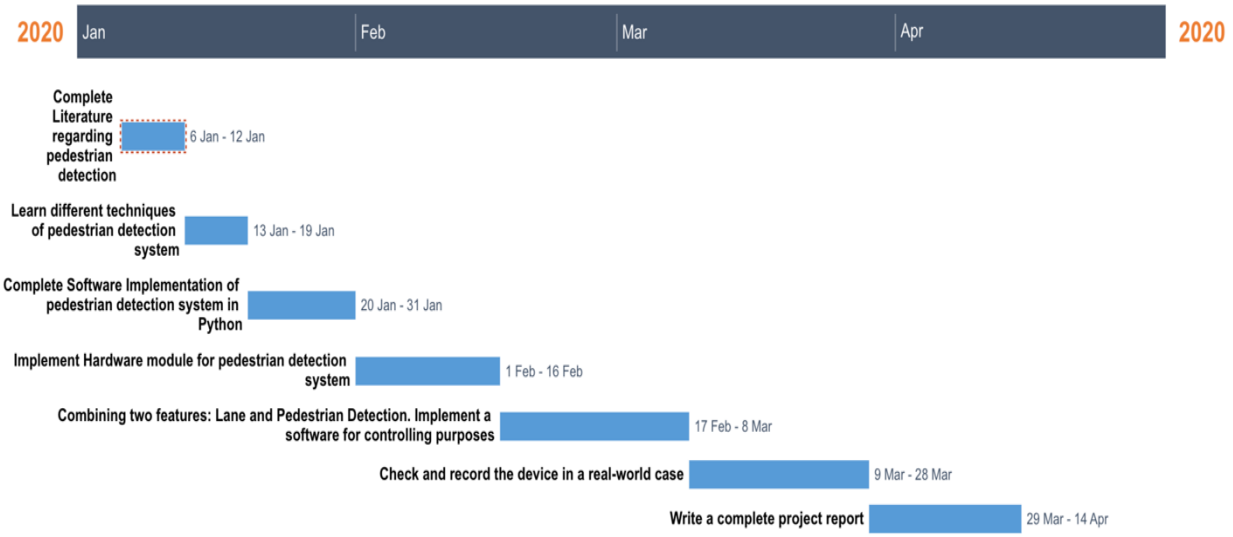

Figure 3. Gantt Chart for the Capstone 2 Project

***SWOT analysis* (limit 1000 words)**

Highlight the strengths, weakness, opportunities and threats of the project.

Figure 4. SWOT Analysis

Skills and background (limit 2000 words)

Highlight the technical skills and experiences that you hope to achieve by the end of the project. Provide the details of the technical background that you currently have to take up the project.

By the end of the project, we hope to gain a broad knowledge in hybrid FPGA, HDL and the programming skills. While writing the Python code for the pane and pedestrian detection, mathematical skills will be significantly improved as well including matrix operations and etc. Currently, we have a good Python programming skill which will help to get a general knowledge regarding the module implementation for each feature (lane detection, pedestrian detection).

***Project Beneficiaries* (limit 2000 words)**

This section describes who and how many people are expected to benefit from the project, both directly and indirectly. It should also discuss how intended beneficiaries have been involved in project design, and their expected role in project implementation and evaluation.

In general, the implementation of this project would have a direct benefit for the car drivers and would make their driving experience more reliable and safer. In addition,

ADAS (Advanced driver assistance system) will increase the driving comfort significantly with the features such as automatic parking, lane keeping, distance keeping. Further investigation of the advantages of the project shows that the drivers are not the only ones who benefit from the project. Decreased number of traffic accidents also means that the amount of emergency transportation and the cost of handling the accidents by the police will substantially decrease. This fact implies that the project beneficiaries are also the government that will save their expenses on handling the road accidents.

Budget and Justification (limit 1000 words)

Most of the components can be found in the university and is provided by the professor: Verilog Software license, ZedBoard, Monitor. In addition to that, project will need Arduino Camera (3 units) – 20USD, consumables (wires, connectors and etc) – 20USD. Camera will be used to take a video as the technique used to implement a device is video based. In total, total budget will be 40USD.

References (minimum 30)

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