IC Chipz

Design Document

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Executive Summary

Development Standards & Practices Used

- Nvidia Jetson board
- YOLO image recognition API
- E-Con Systems camera
- Agile development

Summary of Requirements

- Functional mobile application for monitoring video and scoring
- Computer vision program to process scoring
- Two reliable camera locations for video capture
- Low error rate
- Product functions at 95%+ success rate with night time conditions
- Automated data collection
- Automated integration into analysis systems

Applicable Courses from Iowa State University Curriculum

- SE 319
- COM S 309
- CPRE 288
- SE 329/339

New Skills/Knowledge acquired that was not taught in courses

- Computer vision programming
- Data pipelines and integration techniques

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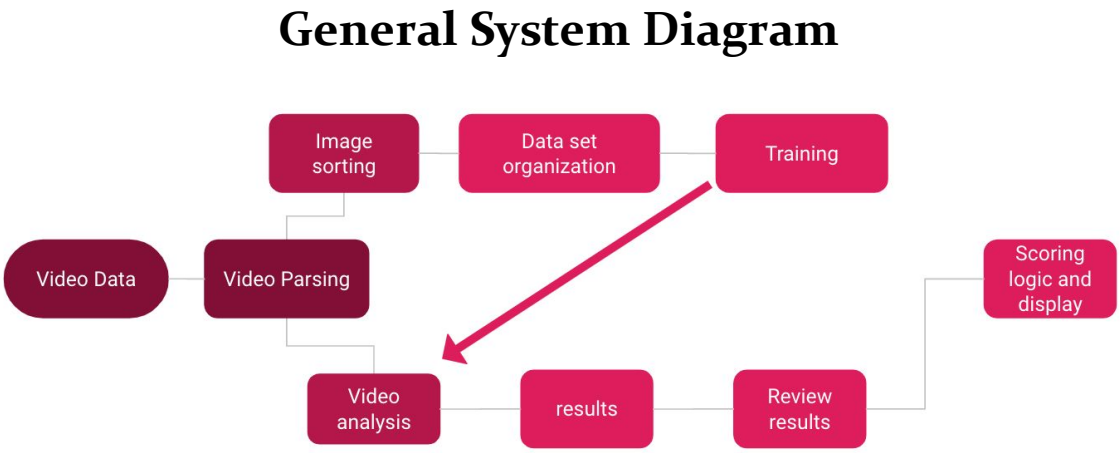

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List of Definitions

Xamarin: A C#, cross platform mobile development toolkit made by Microsoft for Visual Studios

XAML: C# UI templates similar to HTML/XML

YOLO: You Only Look Once, a computer vision algorithm that detects objects in real-time

Data Pipeline: Organization and implementation of the way data flows through various modules

1 Introduction

1.1 Acknowledgement

We want to acknowledge our client for providing us with the necessary equipment to complete this project. This includes: the Nvidia Jetson board, e-con camera, and past project progress from previous groups. We will be using the past project progress in conjunction with new technology.

1.2 Problem and Project Statement

1.2.1 Problem Statement

Skeet shooting should be automatically judged and scored accurately for all tournaments and events. In today's world, there is becoming a shortage of reliable skeet shooting judges. If this problem continues to be ignored, the sport of skeet shooting will eventually be out of options for judges. To solve this issue, the team will use the implementation of an automatic scoring systems to fairly judge skeet shooting events.

1.2.2 Project Statement

As the sport of skeet shooting ages, the ability to find trained referees for the sport becomes more difficult. With a mobile automated scoring system the team plan to open up the sport of competitive skeet shooting to a larger audience by giving them a product that can accurately and affordably track their scores and improvement in the sport without the need for a real life referee.

As the project has already been started by a previous team of engineers, the team will pick up where the previous team left off by first developing a streamlined method for data collection. Data samples are an integral part in the development of a product like this where video data is processed and evaluated by a computer system. With a streamlined data collection platform, the team can then funnel our energy and focus into the development of the actual product with enough data to accurately test or platform.

As the last group worked on hardware purchasing and selection, this group's main goal with be the image processing of the aforementioned data. The group will attempt

to find the best video analysis algorithms to accurately score when a clay pigeon is destroyed against a solid (black of night) colored background. This group believes that by focusing on data captured at night time that the device can more accurately and easily evaluate video data for where the clay pigeon flays and is destroyed.

The team hopes that a finished project can fairly and accurately dictate realtime skeet scores for singled shooters given nighttime conditions, and given this expectation, supply avid shooters with real time feedback without the need of finding a licensed referee.

1.3 Operational Environment

IC Chipz is a product that needs to be designed to be used to judge skeet shooting. This means that it will need to be a product that is durable and can survive in harsh conditions. This product will need to survive these conditions because since skeet shooting is primarily done outside, it will need to be able to survive most outside conditions. In this project, we want IC Chipz to be able to accurately score at night in various types of conditions (rain or shine and hot or cold).

1.4 Requirements

1.4.1 Functional Requirements

The IC Chipz project will have the following functional requirements:

- Mobile application to monitor video, keep records, and show scoring
- Program which uses image processing to decompose video to determine scoring
- Two reliable camera locations for video capture
- Low error rate
- Product functions at a 95%+ success rate given night time conditions with dark background.
- Automated data collection and flow into analysis systems.
- Automated data labeling
- The computer vision algorithm will be You Only Look Once (YOLO)

1.4.2 Economic/Market Requirements

The IC Chipz device economic requirements are to work with the given systems that the client has provided so that no new purchases are required unless absolutely necessary. The IC Chipz device is a personal project of Dr. Duwe's, so it

will have a relatively limited budget compared to a project from a business like John Deere.

1.4.3 Environmental Requirements

The IC Chipz device should work in any outdoor conditions with no change in performance. It should still be able to have the same desired accuracy for every condition on detecting live or dead clay pigeons

1.4.4 UI Requirements

The IC Chipz mobile application should have the following requirements:

- Track the score of the round
- Display whether the clay pigeon is dead or alive after a shot
- The application should output a final scorecard when the round is over
- The ability to review video to dispute a call
- The UI should be organized and easy to use
- The application should store past rounds in a database

1.5 Intended Users and Uses

In IC Chipz, there are two main intended users of this product. The first intended user will be the referees who are judging the skeet shots. They will use this product because it will help them accurately check and see if a clay pigeon has been successfully shot or not, both through the computer vision and through the video feedback through the app. This means that the referees will be able to give the players a much more accurate score. The second main user of this product is the players in Skeet shooting. They will use this product because it will help them keep track of their score without the need of always having a referee. It will also help them because they can use the video feedback in order to study their shots which can be used to help them become better players.

1.6 Assumptions and Limitations

1.6.1 Assumptions

- All skeet shots will take place at night at the request of the client
- The user has an Android/iPhone that they can use so that IC Chipz can send the video feed to that mobile application.
- The skeet range is up to official skeet standards
- The skeet match follows the official skeet match rules

1.6.2 Limitations

- Only be able to visit the test range about once a week
- Weather will be a limitation during the winter
- The Jetson board has the potential to struggle to handle the video that is being transferred to it by the E-Con camera.
- The camera is not an extremely high resolution or FPS camera, which can cause difficulties in picking up small chips flying off of the clay pigeon

1.7 Expected End Product and Deliverables

The IC Chipz final product is a portable scoring device which can be deployed before beginning a skeet round and score 95% of shots successfully. The portable device comes with the ability to pair with a mobile application which acts as a front end interface to the device. Users are able to view current round scores, challenging invalid or wrong scores and access post round information.

- Machine Vision Functional at 95% Accuracy
    - The machine vision portion of the application must meet a 95% accuracy; this means the application must detect a broken clay target 95% of the time.
- Data Collection Mechanism
    - The mobile application and portable device have a data collection mode allowing them to add additional data points to a data set or data sets.
- Auto Data Parsing and Data Labeling
    - With collected data, the portable device shall automatically splice and parse the data into buckets of hits and misses
- Skeet shot scoring [At Night]
    - Machine vision functionality of 95% initially works at night or on darker days
- Skeet shot scoring [At All Times of Day]
    - Machine vision functionality of 95% upgraded to work at all times of day and potentially in unfavorable conditions
- Mobile Application to Review Scores
    - Mobile application has a score review process to allow invalid scores to be challenged and reversed if necessary
- Mobile Application for Post Round Information
    - Post round statistics information displayed after each round

2 Specifications and Analysis

2.1 Proposed Design

IC Chipz has broken down into three sub teams for the project: Mobile Application, Embedded System, and Data pipeline/integration development. Each team is approaching a problem in their area by testing, reviewing, and updating as necessary. The group will continue approaching this design in small steps in sub-teams with the end goal being the image processing of the collected data from the skeet shooting, as the previous years team focused on hardware development.

The team has defined the problem statement with our client, the purpose of the project, and its value. The group has also begun the concept process of the design, The Integration/Data Team has created a top level design of the data flow which will allow the team to find a single concept that works best for our project and continue brainstorming. Approaching the planning, the team has identified the people/team, tasks, task durations, and budget needed. The design planning portion of the project will focus on translating the customer requirements and systems engineering model into a working prototype that can successfully track if a target was hit or not hit under specific conditions.

2.2 Design Analysis

The embedded systems team has created a python script that goes through the train and test sets to establish what is good and what needs to be updated. The team also continued to look into the “Houston” code from last year to determine what is good, and what needs to be changed/updated. After receiving feedback from the client however, the group realized the set may not be working as well as expected and came to the conclusion that it will require updates.

The Integration and Data Team has created a top level design of the data flow from the embedded system to the mobile application which will assist in ideas for the data pipeline.

The Mobile Application Team has tried and tested the existing mobile application code to see if it sufficient enough for the team’s needs and if the UI is simple enough to navigate. The code from the years previous team was not well documented and the

UI was not easily navigated which means the group will have to start from scratch or at the very least use their templating for the new mobile application. The current code also does not include a scoresheet which must be added for requirements. The group will continue to work on areas we thought needed modifications before continuing to the next design element. Gathering data and video from the ISU Skeet team at night will continue to assist us with the Design Analysis.

2.3 Development Process

The team's development process for this project will be Agile which divides the functionality into small parts that can be delivered independently as the team begin to start working on them. This will help to make faster design requirements and get quicker feedback on the groups work from Dr. Duwe.

2.4 Design Plan

The team's design plan is to continue working on respective functionality for the three three sub teams for our project: Mobile Application, Embedded System, and Data pipeline/integration development. As the team continues to work in the Planning and Development stages for IC Chipz we will be working towards a prototype that can track skeet disks and determine if the shot was a hit or miss. Until then, the team will continue to develop and deliver the Functional, Economic, Environmental, and UI requirements to the team's client. Feedback from Dr. Duwe along with data collection from the ISU Skeet Team will allow the team to see what requirements are more crucial and what each smaller team need to focus on more. While the client wants the final design to be able to track any targets under any conditions, the group's first goal is to first have a prototype that can track just one skeet disk and determine if it was hit or not during the night time.

3 Closing Material

3.1 Conclusion

The team has done quite a bit of research and begun to work on the project. The team first researched the previous work done by the previous team as this will determine what further work needs to be done. Next, the team conducted research into the YOLO algorithm in order to look for improvement. Lastly, the team split up into three sub-groups and begun to work on their respective parts, as this allowed members to focus on their strengths and be more productive.

After splitting up into three teams, each team set up their own goals of what they needed to achieve. The mobile team has set goals that reflect redesigning the mobile app. This is the best plan of action because it will allow these members to focus on improving the ease of use for customers/officials who will use this product in the future, and the previous iteration was poorly documented.

The embedded team came up with the goal of fixing the test/training data set and setting up/connecting the Econ camera to the YOLO algorithm. This is the best plan of action for this team because it will allow the team to set up a newer and easier to handle camera then the one used by the previous team. Fixing the test/training set will allow for better accuracy and more efficient result times by the YOLO algorithm.

The computer vision team set goals to use their research to improve the YOLO algorithm when determining if a clay pigeon has been shot or not at night. This is the best plan of action for the computer vision team because it means that it that the team will be able to design an efficient and accurate algorithm while meeting the team goal of determining the clay pigeon status at night.

From this plan of action, the team will be able to create a skeet shooting program that accurately captures and scores skeet shots at night while giving valuable video feedback to the user.

3.2 References

1. J. Redmon and A. Farhadi, *YOLOv3: An Incremental Improvement*, 2018, https://pjreddie.com/darknet/yolo/.
2. E-con Systems. *"ecam_tk1_guvcview Build & Installation Guide."* e-Con Systems, 23 July 2018

3.3 Appendices

N/A