Automatic Tracking of Actors with Intelligent Theatrical Lighting Systems

Design Document

sdmay20-31
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Executive Summary

Development Standards & Practices Used

- The use of infrared camera and OpenCV for actors tracking
- The use of infrared sensor detector for actors tracking
- The use of use of indoor GPS tracking beacons for actors tracking
- The use of receiving and sending antennas for actors tracking
- DMX spotlight is connected through a modem for actors tracking

Summary of Requirements

List all requirements as bullet points in brief.

- The spotlight must autonomously track an actor/actress
- The spotlight must work in an indoor environment like a theater
- The spotlight tracking system must have a reasonable cost

Applicable Courses from Iowa State University Curriculum

CS227, CS228, CS311, CS309, EE224, EE 201, EE 414

New Skills/Knowledge acquired that was not taught in courses

Computer vision/video processing

Group Management

Antenna Transmission

Infrared sensors

Infrared cameras

Table of Contents

List of figures/tables/symbols/definitions (This should be similar to the project plan)

1 Introduction

1.1 Acknowledgement

This project is being made for Story Theater company, located in Ames, under the vision our advisor Mat Wymore. Story Theater company also contributed financial support and provided a programmable spotlight.

1.2 Problem and Project Statement

In small theater organization, autonomous tracking spotlights could provide an easy way to program a show's spotlights, but commercial tracking systems for spotlights are too expensive. An automatic tracking spotlight would allow Story Theater company to save time and money as they wouldn't have to hire a dedicated spotlight person.

This project hopes to design and implement an affordable spotlight tracking system that can be used by Story Theater company in their box theater. The spotlight system should be able to track an actor/actress with after started and with no human intervention. The spotlight system could be programmed to start and stop tracking a person at different positions so it can change its focus at set times.

1.3 Operational Environment

The operational environment for this product would be a theater environment. The space would be a low light environment, and the theater is a box style theater. The product would be kept in an environment that would be at normal room temperatures and moderate dust levels.

1.4 Requirements

- Limiting the budget to $300 for equipment
- Having a functioning autonomous spotlight to track the actor
- Tracking the actor on the stage while moving on x, y, and z axis

1.5 Intended Users and Uses

This project is to be used in Story Theater Company to track a specific actor across the stage autonomously during an act regardless of other lights.

1.6 Assumptions and Limitations

Assumptions:

- The actor will not get out of the stage given parameters.
- The tracking will start from a given point on stage

Limitations:

- The budget is $300.
- There must be no human control to the spotlight besides the movement of the actor.

1.7 Expected End Product and Deliverables

- A Software application, modem, that will receive the location of an actor/actress and move the spotlight accordingly .
- A tracking indoor GPS device that determines the position of the actor on stage and sends data to a wall beacon
- The wall beacon connects back to the modem informing the position (x,y,z) of the actor and move the spotlight accordingly

2. Specifications and Analysis

2.1 Proposed Design

tracking the actor's location on stage:

- 4 wall beacons and a 1 indoor tracking sensor
- infrared camera

Moving the spotlight

- feeding the software the location through a modem

- we have been testing different open source codes to receive the data and control the spotlight.

- We have been playing around with Freestyler software to move the spotlight around.
- Contacted Follow-Me company, but we are not considering them because of their price.
- contacted Marvelmind robotics for their indoor GPS tracking devices, and we are considering their product.

2.2 Design Analysis

The team's progress:

- We have figured out how to move the spotlight using Freestyler software.
- We also detected faces using a regular camera.
- We figured out how to use the wall receiving beacons and the indoor tracking device to track the location of the actor.
- The modem receives the location information, and sends it to the spotlight to move accordingly.

What worked well:

- Freestyler website has worked fine, and the spotlight moved according to the commands from the software.
- The tested camera detected faces with some challenges.
- We still need to buy the products, indoor tracking sensor, to try them out, but the Youtube video shows that it works well, https://www.youtube.com/watch?v=lImQtorAezU. I also have been contacting the customer service of the company, Marvelmind Robotics, asking them about their indoor tracking device.

Observations and ideas:

- The camera needs to be accurate detecting faces in order to link it to Freestyler software.
- The team will most probably be buying the indoor tracking GPS kit from Marvelmind Robotics, to place around the theater and test with the spotlight.

Strengths and weaknesses:

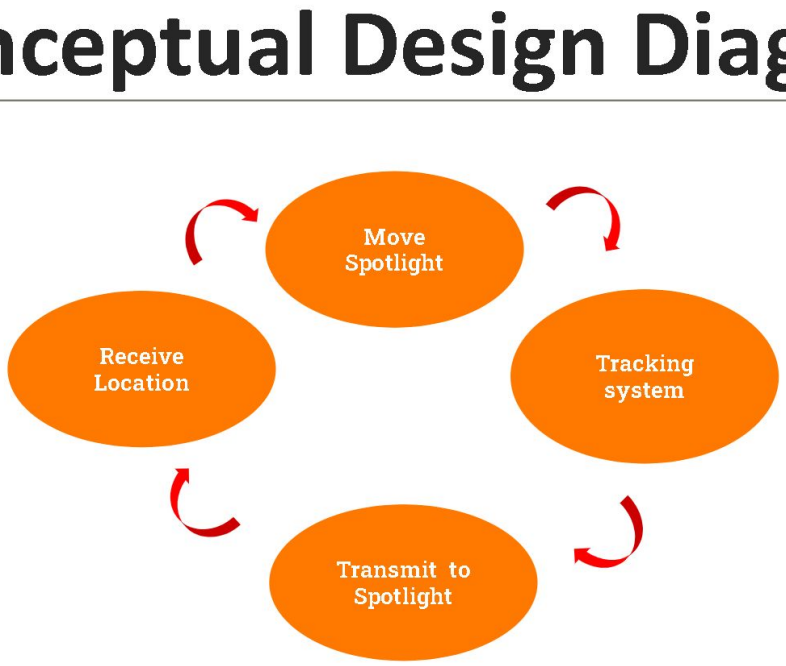
- The indoor tracking GPS kit is accurate (+/- 2 cm) tracking locations.
- The infrared camera is still not solid for face detection.

2.3 Development Process

The team is following Agile process in terms of planning and testing. The team has two meetups per month. During these meetups, we plan what to design (antennas, infrared camera, sensor kit) throughout the month. After that, the team research, and prepare the needed parts. Next, we test the spotlight with the prepared devices to see if they work. Finally, we evaluate the performance of the spotlight based on the tested spotlight.

Reaching out for tracking companies has been helpful for considering the exact devices needed for this project. As of now these are the devices we are planning to buy: **Starter Set IA-01-2D**, **Beacon Mini-RX,** and **Inverse Architecture in the Paired Beacons configuration.**

2.4 Design Plan



3. Statement of Work

3.1 Previous Work And Literature

People tracking has been done in many ways before but usually the solutions that are there, are not exactly tailored towards theater and if they are they are way too expensive for our budget. This research has been done by our client as to reach to the conclusion of building an affordable easy to use tracking system. We have looked at other research work that was similar to what we want to do. for example this is one research we looked at:

Jayanth, S Narasimha & Teja, N & Bhagyasri, Y & Shahapur, Kiran. (2016). RF based Remote Stage Lighting Controller. 10.13140/RG.2.1.4553.8165.
https://www.researchgate.net/publication/302590662_RF_based_Remote_Stage_Lighting_Controller

The previous work talks about using RF transmitter to control DMX lighting , we gain interesting things from the documents as to how a control system was built to interface into the DMX lighting as well as using an RF transmitter to wirelessly control the DMX lighting which might give us an idea about how to track an actor from far away.

One of the products we looked at for tracking is this kit from Pozyx that uses wireless communication but it is ridiculously expensive, priced at 1050 euros per kit. https://www.pozyx.io/shop/product/creator-kit-65 this could potentially automate much of our project and we would be just left to make a control hub for the lighting. However this is not a feasible solution taking in consideration our budget.

3.2 Technology Considerations

The tracking methods we are considering are

Using an antenna receiver along with an RF signal emitter to track the actor/actress

Using an infrared camera along with open source computer vision framework to track the actor/actress

Method	Accuracy (%)	Cost	Advantage	Disadvantage
Antennas &transmitter	%99	High	Have the choice of tracking manually or automatically	Too expensive
Infrared Camera	------	Low	Potential to easily switching targets without multiple tracking devices	Hard to work with, inconsistent tracking.
Localino	+/-10 cm	$159	It has a scalability, user-friendly, and high-quality design and open source software	----------
Indoor GPS	Precise (+/-2cm)	Low-moderate	Precision is exact and performs well indoors	Beacons must be mounted on the walls around the corners of the stage.

3.3 Task Decomposition

1. The first thing the product will have to do is locate the precise position of an actor/actress on the stage
2. Next the position data will have to be interpreted by a software controller.
3. Next a software controller should send signals to the spotlight through the USB interface device.
4. The spotlight will receive the signals and move accordingly.

3.4 Possible Risks And Risk Management

The RF tracking equipment may be a cost issue. An infrared camera would also be costly and needed for the low light level environment. Computer vision tracking is also a complex topic and may require a lot of research and hard work to use effectively.

3.5 Project Proposed Milestones and Evaluation Criteria

- The spotlight is controllable by a programmable software.
- The RF tracking can track the position of the actor/actress
- The computer vision software can track the position of the actor/actress
- The tracking system can connect to the programmable controller and send the position data to the controller

3.6 Project Tracking Procedures

We will use group messaging to keep in constant contact with each other and to inform others about progress. We can also use Gitlab issues and milestones to track the progress of the application.

3.7 Expected Results and Validation

The expected results will be a computer application along with a tracking system that works together to control a DMX spotlight. The spotlight will track an actor/actress autonomously and will be able to be programmed to start and stop tracking through the application.

The tracking should work at least 75% of the time in a low light level environment.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

Project development will be divided into three different phases, by the end of each phase a set of deliverables expected crospond to that phase. Phase one consists of research different types of software that could use to control spotlight. A suitable tracking system will also be decided. Phase two implementing the hardware for the tracking system and spot light control. Phase three testing and final documentation.

Phase Number	Description of work	Estimated Number of Weeks	Estimated Number of Agile Sprints	Comments
Phase 1	Theatrical Spot Light Control System and Automatic Tracking System research. ● Research different options for how we control the spot light. ● Research different options for a tracking system that support the spotlight. ● Research on the ability of integrating the spot light control software and automatic tracking system.	13	3	This will be the start of the first semester
Phase 2	Implementing the hardware for the tracking system and spot light control. ● integrating the software and hardware for the tracking system ● integrating spotlight software with DMX ● integrating the spot light with the tracking system.	TBD	TBD	This will be the start of the second semester
Phase 3	Testing and Final Documentation	TBD	TBD	

Sprint Number	Phase Number	Start Date	End Date
1	1	Tuesday, Sept. 3, 2019	Tuesday, Oct. 2, 2019
2	1	Wednesday, Oct. 3 2019	Monday, Nov. 4, 2019
3	1	Tuesday, Nov. 5, 2019	Sunday, Dec. 8, 2019

4.2 Feasibility Assessment

one of the challenges could be developing software to interact with the client equipment.

buying some hardware for this project will be another challenge.

Realistic projection of what the project will be. State foreseen challenges of the project.

4.3 Personnel Effort Requirements

our team consists of two computer engineer who is responsible for developing software.

three electrical engineer working on RF signal and antenna design.

4.4 Other Resource Requirements

some material might be required to conduct the project, and we agreed with the client to provide these materials. other resource, we can share some money to complete the project.

4.5 Financial Requirements

at this point no required financial resources.

5. Testing and Implementation

We have not yet built anything to be tested yet.

5.1 Interface Specifications

The spotlight will be controlled by DMX signals sent with the help of the Open Lighting Architecture framework.

5.2 Hardware and software

A simple camera that would be used to record the spotlight + tracking system in action will be used. The video can then be analysed further and metrics like the percent of time the spotlight tracked an actor can be calculated.

5.3 Functional Testing

Software testing will use a testing framework like Junit, or Mockito.

5.4 Non-Functional Testing

Testing for performance, security, usability, compatibility

5.5 Process

The spotlight tracking system will be tested by using a camera to record the system working on a predetermined course. The video will be looked at and the tracking percent will be calculated.

5.6 Results

N/A

6. Closing Material

6.1 Conclusion

So far, we have done most of the research and design alternatives to get the ideas of how to implement our project. We want to detect the location of an actor on the stage and have a spotlight follow him autonomously. We are still choosing the method to be used in the project for detection and controlling.

6.2 References

No references so far.

6.3 Appendices

N/A

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc. PCB testing issues etc. Software bugs etc.