**NAZARBAYEV UNIVERSITY**
**SCHOOL OF SCIENCE AND TECHNOLOGY**
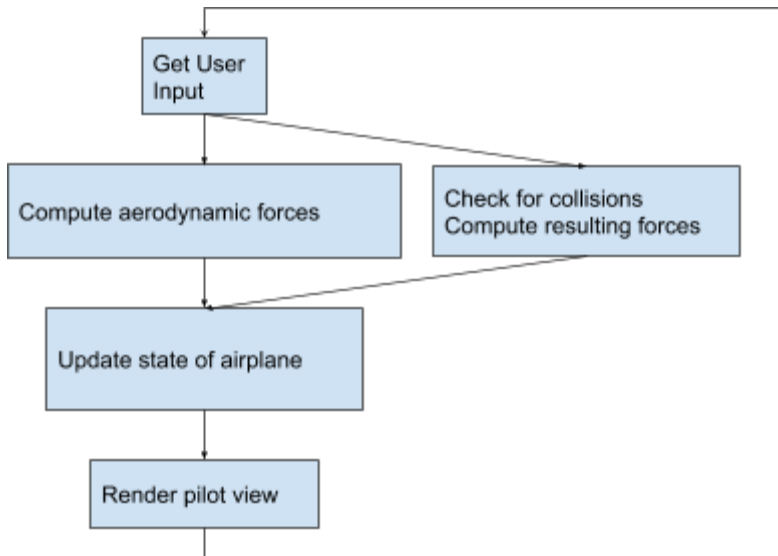
**Computer Science Department**
**Senior Project Proposal**

| Proposer: | Hans de Nivelle (Associate Professor, Computer Science) |
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| Topic: | Flight Simulation Program |
| Team Members: | Alisher Shakhiyev, Alen German, Auyez Zhumashev |
| **Description** | |

1. Project Description:

   Write a 3D flight simulator with 3D mechanics, 3D graphics, collision detection, terrain, and interactive user input.

   The motivation and purpose is to make students understand the theory behind flight simulation, and to be able to implement it: Understand 3D mechanics, numerical real time differential equation solving, understand how to represent scenery, understand collision detection, how to detect user input, and the basics of computer graphics.

2. System Description:

   The project will consist of implementations of

   - a 2D flight physics model
   - a 3D graphics engine.
   - 3D models and shader assets (Spring semester)
   - a 3D collision detection system
   - terrain (Spring semester)
   - a 3D flight physics model (Spring semester)

3. System Design:
   Workflow Diagram

```
Get User
Input

Compute aerodynamic forces        Check for collisions
                                  Compute resulting forces

Update state of airplane

Render pilot view
```

ER Diagram
The simulation won't keep track of any data, so ER Diagram is just an empty whitespace.

System modelling (How to model the problem of interest)

- 2D flight physics model from [0] will be used.

Methodology (Techniques that are used in the project and why choose them)

- Pair programming. The project will include some technically difficult tasks that can't be neatly divided among multiple people but are too hard for a single student.
- Students will review each other's code.

Functionality (How to implement the above techniques. there should be some diagrams.)

(Not applicable)

Optimization (How to optimize the techniques)

(Not applicable)

4. System evaluation criteria if any

The simulation will be checked against an existing 2D model, and against published performance parameters. We will try simple manoeuvres (like take off and landing)

5. Plan B: basic 3D collision detection(no wheels, no friction) and simple 3D physics

## Objectives

The main goal of this project is to create a real time simulation of an airplane. To achieve the main goal, the following objectives should be completed:

- Build real time application with 3D graphics support ( Basic 3D game engine that can load models, support basic animation and lighting implemented using OpenGL )
- Build 2D flight physics simulation ( 2D flight simulation written in C++ using SFML library )
- Integrate with existing 3D collision detection solutions ( Integrate with physics engines like ODE and Bullet), or implement our own collision detection
- Build 3D flight physics simulation

The main objectives that should be completed in 1st semester:

- Build 2D flight physics simulation ( 2D flight simulation written in C++ using SFML library )
- Build basic real time 3D application ( Basic 3D game engine that can load models, support basic animation and lighting implemented using OpenGL )

| | |
|---|---|
| - | Integrate with existing 3D collision detection solutions ( Integrate with physics engines like ODE and Bullet) or implement own collision detection. This will be decided in the beginning of the first semester. |

**Deliverables:**

-   1st Semester:

    ●   2D flight simulation written in C++ using the SFML library
    ●   Basic 3D game engine that can load models, support basic animation and lighting implemented using OpenGL

-   2nd Semester:

    ●   Full 3D flight physics simulation.
    ●   3D collision detection with friction.
    ●   Improved renderer

**Tasks to be Accomplished:**

| Week (1st week starts on 28th Jan) | Alisher | Alen | Auyez |
|---|---|---|---|
| 1 | Fix the existing 2D physics model | Design renderer architecture | Design renderer architecture |
| 2 | Study basic 3D collision detection theory | Make a beautiful sky | Heavily refactor renderer |
| 3 | Rewrite 2D physics into 3D | Make beautiful water | Implement shadows |
| 4 | Validate basic 3D simulation | Create scenery objects | Refactor terrain code Rescale terrain |
| 5 | Validate overall 3D simulation | Clean up renderer and terrain code | Render scenery objects |
| 6 | Validate overall 3D simulation | Make splatmaps affect terrain | Render scenery objects |
| 7 | Implement basic 3D collision detection | Try to load Kazakhstan's terrain | Implement beautiful clouds |
| 8 | Study advanced 3D collision detection theory (wheels, friction) | Study 3D collision detection code | Implement animations |

| 9 | Implement advanced 3D collision detection | Study 3D physics theory and code | Implement instrument panel |
|---|---|---|---|
| 10 | Implement advanced 3D collision detection | Fixing 3D collision and 3D physics bugs | Implement UI |
| 11 | Performance optimization | Bug fixing | Performance optimization |
| 12 | Final report, presentation, poster | Final report, presentation, poster | Final report, presentation, poster |

| Hardware and Software Requirements |
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| The minimal achievement for the first semester is a two dimensional flight simulator which has a reasonably realistic flight model and controllability. This includes:<br><br>● Realistic lift and drag forces exerted on the plane<br>● Two-dimensional torque<br>● Realistic takeoffs and landings<br>● Keyboard or mouse input reading<br>● Environmental effects, at least the air pressure change with height<br><br>In the second semester, the simulator must be extended to a three dimensional version. The minimal achievement consists of 3D graphics, and ground collision (contact) detection and adequate movement in 3D space. |

| References |
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| [0] http://www.ii.uni.wroc.pl/~nivelle/teaching/flightsim2016/twodimensional.pdf |

## Term Schedule

| | | To be always filled by adviser during meeting with students | | |
|---|---|---|---|---|
| Week Number | Task Assignment | Date Completed | Comments | Signature |
| 2 (~Feb 8) | Renderer is refactored, perfectly working 2D model | | | |
| 4 (~Feb 22) | Basic 3D physics model | | | |
| 6 (~Mar 8) | Final terrain, reasonable full 3D physics model | | | |
| 8 (~Mar 22) | Basic 3D collision, | | | |
| 10(~Apr 5) | 3D graphics, Terrain, 3D Collision Detection | | | |
| 12 (~Apr 19) | Presentation accomplishments, encountered problems and proposed solutions. This is not a Technical presentation but rather advancement check, Interim Report (end of term paper)<br><br>End of first term | | | |