CS464 Term Project Progress Report

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Project Title:

Making the Models of Composite Armor Systems by Using Reinforcement Learning

Introduction

We are building a system which makes the models of Composite Armor System. To achieve this, we are using Reinforcement Learning. We are using CPS Technologies High-Tech ceramic tiles on our model. “CPS Technologies (CPS) has developed a technology for improving the toughness of ceramic tiles in composite armor systems by selectively reinforcing them with metal and metal matrix composites (MMC) and then packaging them in a hermetic layer of high-pressure cast aluminum. Armor integrators can translate this improvement into more consistent ballistic performance, reduced need for gap-fillers, and improved ballistic performance near tile edges.”[1] In our case we are using hexagonal and square ceramic tiles, Figure 1. Edges of both hexagonal and ceramic tiles are 4 cm. For the cases in which hexagonal ceramic tiles are chosen to be used, there are two different types of half hexagonal tiles as shown in Figure 2. For square tiles half square alternative is also used, Figure 2. By using reinforcement learning, we will create a model which consists minimum number of ceramic tiles to cover maximum area. The reason behind choosing reinforcement learning is that we have a very-limited number of pre-formed models and we need to select junction points on them. We decided to go with negative reinforcement learning. Since, it will be more effective in terms of time and effort. We will use two data types. The first is a canvas which represents the part of armored vehicle and could be either square or rectangle. Other data is CPS Ceramic Tiles which fulfills the canvas and smaller than canvas. These tiles could be used as half or full size. In our model, the agent will start to add bunch of tiles(full or half) to the canvas and we will calculate the area of gaps and the number of tiles used. After that, we penalize excessive usage of shapes and total area of gaps. We will prioritize total area of gaps; therefore, we will give mentioned situation higher penalty term. Secondly, we will quantize the length of canvas and tiles, cutting and placement will be quantized as well. The quantization is made because of the performance issues, if we will use the floating point numbers to describe the lengths of tiles, it could take longer time to achieve the result, the speed of training will be diminished, the memory will be limited; therefore, we cannot store all of the floating point values, and at the end, we will have an irreducible error, which can be compensated using one more tile.

Figure 1. Hexagonal and Square ceramic tiles [1]

Figure 2. Different half hexagons, square and half square shapes

The Progress of the Project

Canvas in this project is the body modules of armoured vehicles. Ejder Yalcin by Nurol Makina is chosen as the vehicle and its side doors, front right bumper section and front right fender selected initially to have different geometries to test the learning of the algorithm. Shapes and dimensions are listed below.

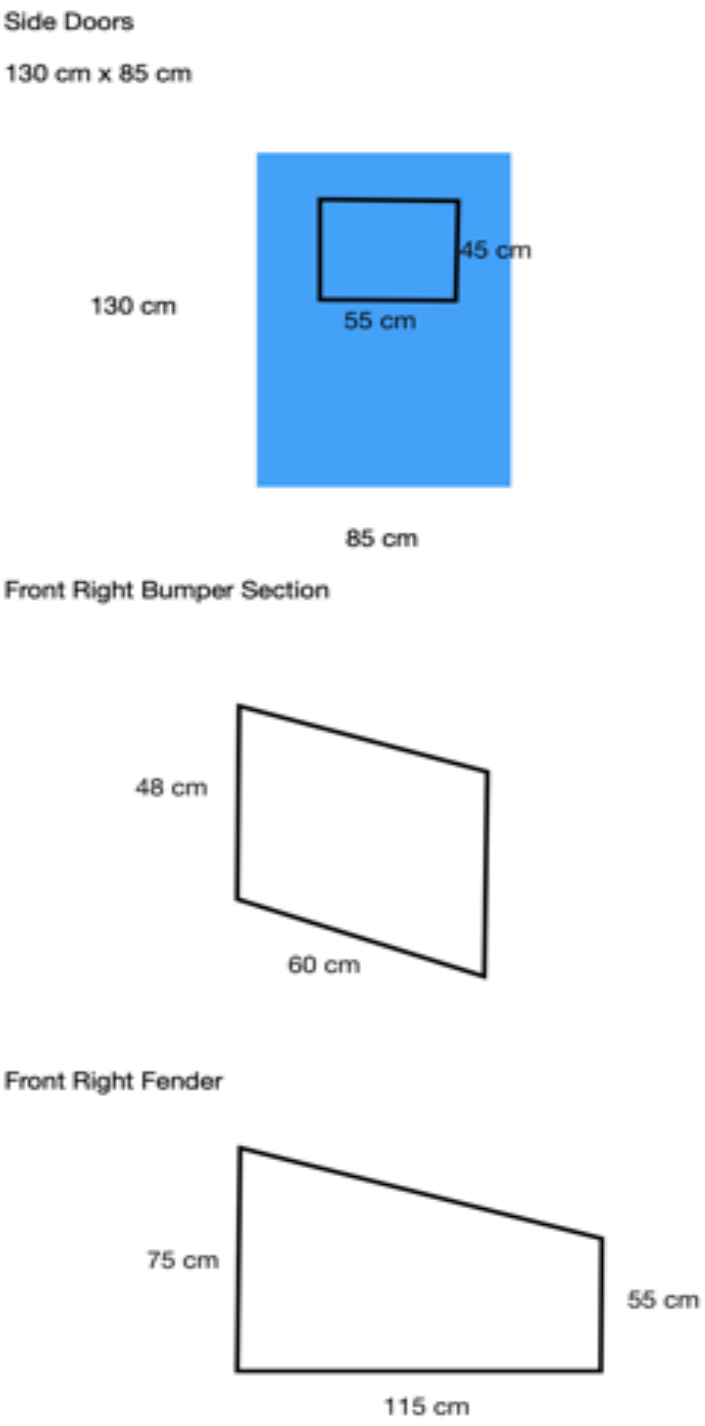

Figure 2. Canvas dimensions [2]

We researched about the reinforcement learning. We watched lessons from David Silver. Based on our researches and learnings, we designed an algorithm. We decided to use Negative Reinforcement, we will give negative rewards for empty areas in the canvas then, calculate overall score. We choose python to implement our project

According to our design, we decided to implement GUI, first. Because, in that way we could observe how our agent place the hexagons and squares. We implemented a canvas and hexagons, squares in GUI, by tkinter library. In our case, canvas will be the area which our hexagons and squares will be placed in, which means this canvas will be the area of the armor in real life, which will cover with the hexagonal and square tiles. We designed our algorithm based on taken canvas height and width from user, yet hexagonal and square tiles' length of edges are constant, and taken 4 cm. For now, in our project, we can place these hexagons and squares into the canvas, without any overlapping. We restricted overlapping since, our agent will place these shapes randomly but not one shape on top of the other.

The Remaining Part of the Project

We will set our agent to place shapes on the canvas and get rewarded based on the final placement. We are planning to use the library to do reinforcement learning, but if we have time, we will design our algorithm.

Hence, the remaining part of the project is, the agent should be able to place hexagons or squares randomly, then based on final result it should be rewarded. After agent tried all of the possibilities, it should be provide best placement of the shapes, based on the highest score that agent got. We first implement a random shape picker for the agent. Then, agent will choose shapes randomly and place them to random coordinates of the canvas. Since agent pick and place the shapes randomly, it will remain pick and place shapes until there is not enough space to place any hexagon and square. We already restricted overlapping, hence agent will not place any shape on the top of another previously placed shape. After there is not enough space for agent to place any kind of shape, we will give a score based on remaining empty spaces in the canvas. For each 1x1(since we implemented our project integer based) empty area we will give a negative score. After this observation, our agent is planned to get a higher score than the previous. And finally, it should choose the placement which will give the highest score.

The Division of The Work

Can, Ayca implemented the GUI part and tried to get results by using Python library. Ege provided the size of canvas and other components. Ege and two Emre worked on the report All of us brainstormed the milestone, the aim and the technical steps of the project and the requirements of the proposal report.

References

[1] B. Wang, “Aluminum encapsulated ceramic tiles for hybrid armor,” 1761eac3b1967fa6e4cafb6af110abcc-1, 07-Apr-2017. [Online]. Available: https://www.nextbigfuture.com/2011/01/aluminum-encapsulated-ceramic-tiles-for.html. [Accessed: 29-Oct-2019].

[2] Nurolmakina, “Ejder Yalçın,” *Nurol Makina*. [Online]. Available: https://www.nurolmakina.com.tr/tr/urunler/ejder-yalcin. [Accessed: 24-Nov-2019].