Using A* algorithm for path finding in games

A MINI PROJECT REPORT

18CSC305J - ARTIFICIAL INTELLIGENCE

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BONAFIDE CERTIFICATE

Certified that Mini project report titled **"Using A* algorithm for path finding in games"** is the bonafide work of **Ginnela Jayadeep(RA2011003010397),Puneeth Pemmasani (RA2011003010391),RishirajChilveri(RA2011003010353),Bhonagiri Ajay Kumar (RA2011003010400)**who carried out the minor project under my supervision. Certified further, that to the best of my knowledge, the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

The A* algorithm is a commonly used pathfinding algorithm in video games, allowing computer-controlled characters to efficiently navigate complex environments. This algorithm works by using a heuristic to estimate the cost of reaching a goal state from any given position in the environment, and then searching for the path with the lowest overall cost. This abstract summarizes the key concepts of the A* algorithm and its applications in video game development, including the use of various heuristics and data structures to optimize the algorithm's performance. It also discusses some of the limitations and challenges associated with implementing A* in game development, including the need to balance accuracy and computational efficiency to ensure a smooth and engaging gameplay experience.

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ABBREVIATIONS

2D	Two Dimension
3D	Three Dimension
CPU	Central Processing Unit

CHAPTER 1

INTRODUCTION

One of the greatest challenges in the design of realistic Artificial Intelligence (AI) in computer games is agent movement. Pathfinding strategies are usually employed as the core of any AI movement system. Pathfinding strategies have the responsibility of finding a path from any coordinate in the game world to another. Systems such as this take in a starting point and a destination; they then find a series of points that together comprise a path to the destination. A games' AI pathfinder usually employs some sort of precomputed data structure to guide the movement. At its simplest, this could be just a list of locations within the game that the agent is allowed move to. Pathfinding inevitably leads to a drain on CPU resources especially if the algorithm wastes valuable time searching for a path that turns out not to exist.In this project we have presented the use of A* algorithm for path finding in a 2D game due to it being complete and its ability to find the optimal path at a low cost.

CHAPTER 2

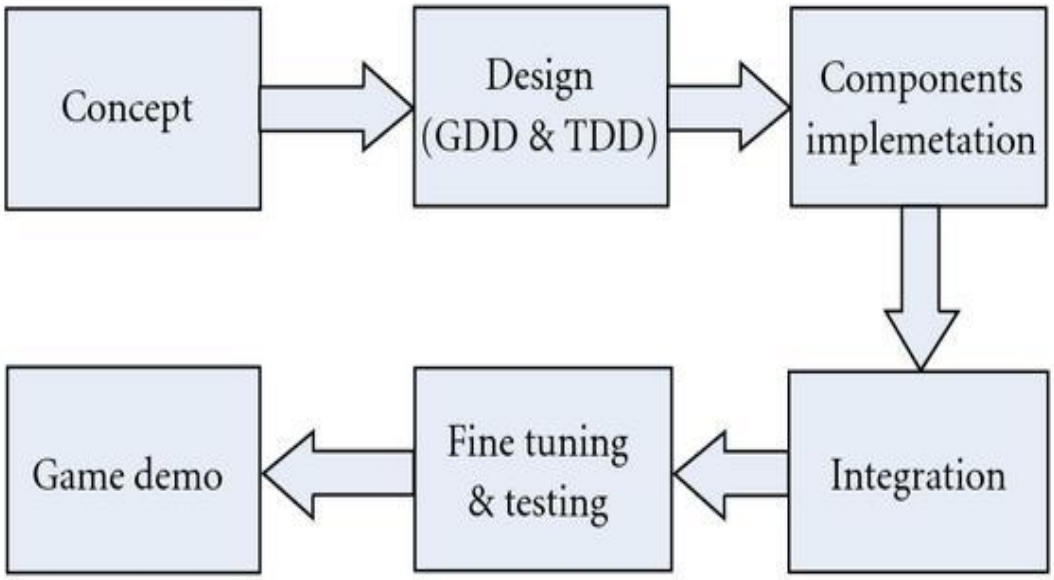
LITERATURE SURVEY

Game is made of many components, and game design process has to go through many steps. However, making a complete commercial game is not our intention; our main focus is to build a basic game to demonstrate the research idea. For this purpose, we follow a simple game design process as shown in Figure. In Concept phase, we have to brainstorm the game story, look for concept arts, and choose the development platform. Design phase is mainly to design models, game levels based on design documents. Components Implementation phase is to implement components such as user interface, visual and audio effects, game mechanics, and AI. The next steps are integration, fine tuning, and testing before launching the game demo. The most challenging issue is how to implement machine learning feature nicely without affecting the game flow. Figure shows the overall project architecture where the left part is game design process, and the right part is the framework for RL.

The goal of a literature survey on finding path in games using A* algorithm is to synthesize and summarize the existing research in this area, identify gaps in current knowledge, and suggest future directions for research and development. This survey can be a valuable resource for game developers, researchers, and students who want to understand and apply A* algorithm for pathfinding in video games

CHAPTER 3

SYSTEM ARCHITECTURE AND DESIGN



CHAPTER 4

METHODOLOGY

We have implemented this project in unity as a 2D project. The aim of the project is to have a player object and an enemy object. The enemy object will home in on the player object using pathfinding powered by the A* algorithm.

A) Setting up the project -

We start this project by using the base 2D game preset available in Unity. To setup the base of the project we used 2D assets available for free on the Unity Asset Store. For this project, we have utilized the Sunny Land asset from the Unity store. We follow this up by building a map using the assets we imported from the Unity Store and building the collision mesh for all objects and setting the appropriate layers for the foreground and the background.
The map we will be using.
Next, we create and animate the characters. We have created two characters, one, which will be controlled by the player and the other which will be controlled by the AI. We first set up the player character. We do this by creating the game object and adding the appropriate collision meshes and player controller components. Next we set up the bird enemy AI character. We setup the collsion mesh for it as well and animate it as well.

Creating and animating the player character
Creating and animating the enemy bird AI character.

At the end of this phase we are able to move the player around the map using our controls but thats about all that can be done in the game.

B) Implementing path finding using A*(creating the graph)

Next we implemented the pathfinding algorithm in unity. Unity has in built AI pathfinding support, however, this was only intended to be used for 3D navmeshes and not 2D. Therefore, we build a custom solution using A* algorithm utilising some inbuilt unity tools.

The game map has to be prepared or pre-processed before the A* algorithm can work. This involves breaking the map into different points or locations, which are called nodes. To achieve this we use an inbuilt Unity tool to create a graph. We then use the layers which we had previously created to allow the tool to be able to detect the obstacles.

CHAPTER 5

CODING AND TESTING

Algorithm -

1. Initialise openList and closedList.
2. Push startNode in openList
3. Initialise g cost to max value
4. Create function to calculate h cost(distance to end node) 5. Create function to calculate f cost(f cost= g cost+h cost) 6. Create function to find lowest f cost node
7. Loop while(openList.count>0)
8. Initialise currentnode to lowest f cost node
9. If currentnode is end node return path and exit loop
10. Remove current node from open list and add it to closed list 11. Else return null

Code -

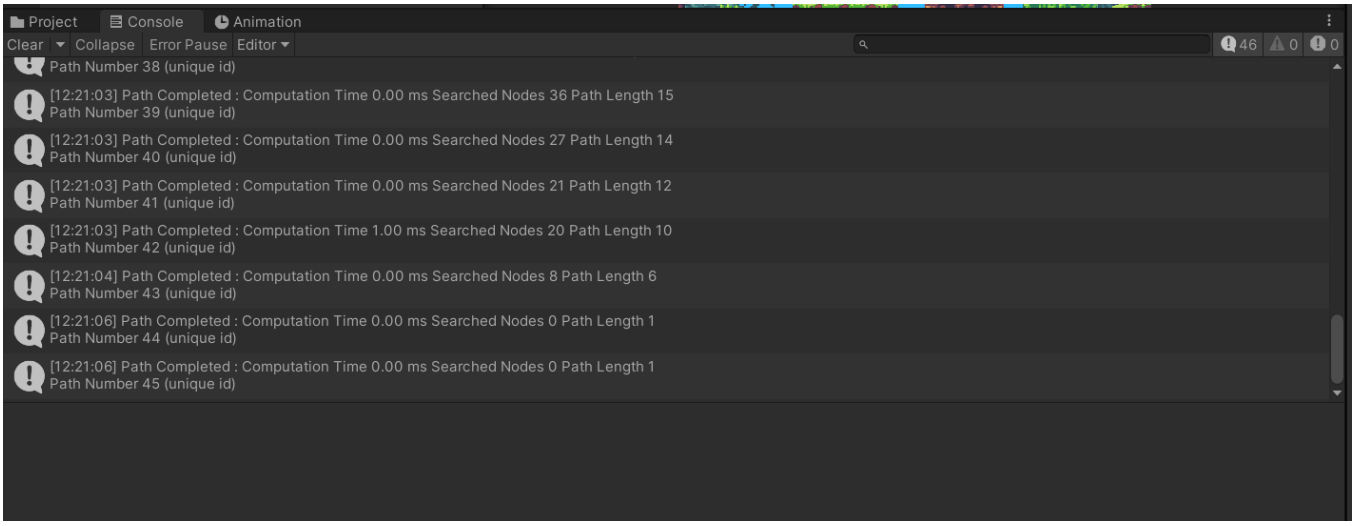
```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Pathfinding {

 private const int MOVE_STRAIGHT_COST =
10;  private const int
MOVE_DIAGONAL_COST = 14;

 public static Pathfinding Instance { get; private set; }

 private Grid<PathNode> grid;
 private List<PathNode> openList;
 private List<PathNode> closedList;

 public Pathfinding(int width, int height) {
 Instance = this;
 grid = new Grid<PathNode>(width, height, 10f,
Vector3.zero,  (Grid<PathNode> g, int x, int y) => new
PathNode(g, x, y));  }

 public Grid<PathNode> GetGrid() {
 return grid;
 }
```

```
 public List<Vector3> FindPath(Vector3 startWorldPosition,
Vector3  endWorldPosition) {
 grid.GetXY(startWorldPosition, out int startX, out int
startY);  grid.GetXY(endWorldPosition, out int endX, out int
endY);

 List<PathNode> path = FindPath(startX, startY, endX,
endY);  if (path == null) {
 return null;
 } else {
 List<Vector3> vectorPath = new
List<Vector3>();  foreach (PathNode pathNode in path)
{
 vectorPath.Add(new Vector3(pathNode.x,  pathNode.y) *
grid.GetCellSize() + Vector3.one * grid.GetCellSize()  * .5f);
 }
 return vectorPath;
 }
 }

 public List<PathNode> FindPath(int startX, int startY, int endX,
int  endY) {
 PathNode startNode = grid.GetGridObject(startX,
startY);  PathNode endNode = grid.GetGridObject(endX,
endY);

 if (startNode == null || endNode == null) {
 // Invalid Path
 return null;
 }

 openList = new List<PathNode> { startNode
};  closedList = new List<PathNode>();

 for (int x = 0; x < grid.GetWidth(); x++) {
 for (int y = 0; y < grid.GetHeight(); y++) {
 PathNode pathNode = grid.GetGridObject(x,
y);  pathNode.gCost = 99999999;
 pathNode.CalculateFCost();
 pathNode.cameFromNode = null;
 }
 }

 startNode.gCost = 0;
 startNode.hCost = CalculateDistanceCost(startNode,
endNode);  startNode.CalculateFCost();
```

```
 PathfindingDebugStepVisual.Instance.ClearSnapshots();  Pa
thfindingDebugStepVisual.Instance.TakeSnapshot(grid,  start
Node, openList, closedList);

 while (openList.Count > 0) {
 PathNode currentNode = GetLowestFCostNode(openList);  if
(currentNode == endNode) {
 // Reached final node

PathfindingDebugStepVisual.Instance.TakeSnapshot(grid,
currentNode,  openList, closedList);

PathfindingDebugStepVisual.Instance.TakeSnapshotFinalPa
th(grid,  CalculatePath(endNode));
 return CalculatePath(endNode);
 }

 openList.Remove(currentNode);
 closedList.Add(currentNode);

 foreach (PathNode neighbourNode in
GetNeighbourList(currentNode)) {
 if (closedList.Contains(neighbourNode)) continue;  if
(!neighbourNode.isWalkable) {
     closedList.Add(neighbourNode); continue;
 }

 int tentativeGCost = currentNode.gCost
+  CalculateDistanceCost(currentNode,
neighbourNode);
 if (tentativeGCost < neighbourNode.gCost)
{  neighbourNode.cameFromNode = currentNode;
            neighbourNode.gCost = tentativeGCost;
                    neighbourNode.hCost =
CalculateDistanceCost(neighbourNode, endNode);
 neighbourNode.CalculateFCost();

 if (!openList.Contains(neighbourNode))
{  openList.Add(neighbourNode);  }
 }

PathfindingDebugStepVisual.Instance.TakeSnapshot(grid,
currentNode,  openList, closedList);
 }
 }

 // Out of nodes on the openList
```

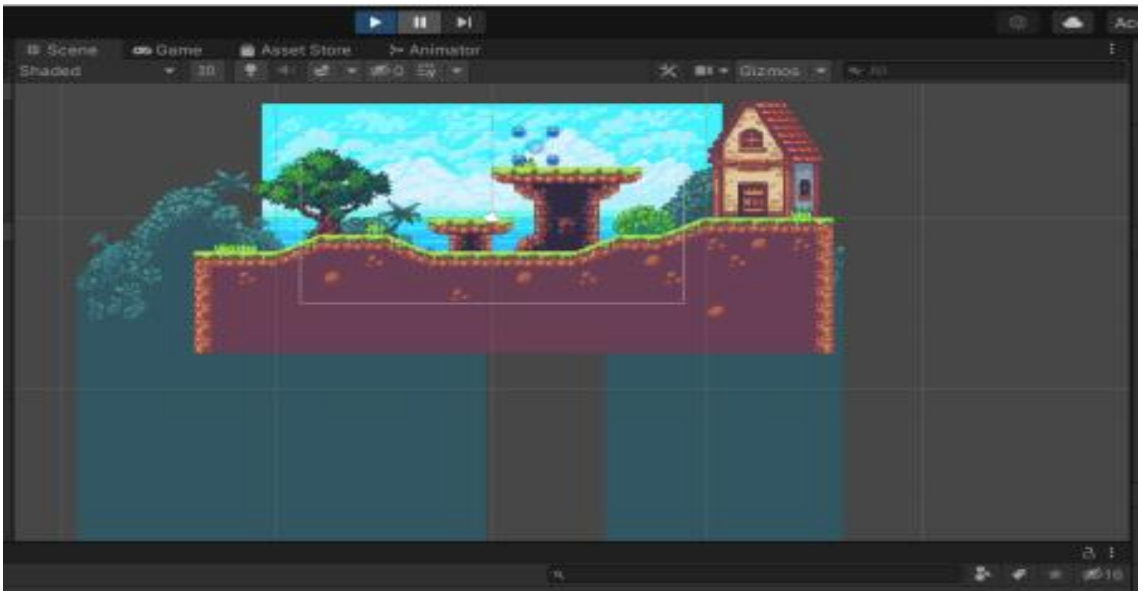
```
 return null;
 }

 private List<PathNode> GetNeighbourList(PathNode
currentNode)  {
 List<PathNode> neighbourList = new List<PathNode>();

 if (currentNode.x - 1 >= 0) {
 // Left
 neighbourList.Add(GetNode(currentNode.x -
1,  currentNode.y));
 // Left Down
 if (currentNode.y - 1 >= 0)
neighbourList.Add(GetNode(currentNode.x - 1,
currentNode.y - 1));  // Left Up
 if (currentNode.y + 1 <
grid.GetHeight())  neighbourList.Add(GetNode(currentNode.
x - 1, currentNode.y + 1));  }
 if (currentNode.x + 1 < grid.GetWidth()) {
 // Right
 neighbourList.Add(GetNode(currentNode.x +
1,  currentNode.y));
 // Right Down
 if (currentNode.y - 1 >= 0)
neighbourList.Add(GetNode(currentNode.x + 1,
currentNode.y - 1));  // Right Up
 if (currentNode.y + 1 <
grid.GetHeight())  neighbourList.Add(GetNode(currentNode.
x + 1, currentNode.y + 1));  }
 // Down
 if (currentNode.y - 1 >= 0)
neighbourList.Add(GetNode(currentNode.x,
currentNode.y - 1));  // Up
 if (currentNode.y + 1 < grid.GetHeight())
neighbourList.Add(GetNode(currentNode.x, currentNode.y + 1));

 return neighbourList;
 }

 public PathNode GetNode(int x, int y) {
 return grid.GetGridObject(x, y);
 }

 private List<PathNode> CalculatePath(PathNode
endNode) {  List<PathNode> path = new
List<PathNode>();  path.Add(endNode);
 PathNode currentNode = endNode;
```

```
 while (currentNode.cameFromNode != null)
{  path.Add(currentNode.cameFromNode);  current
Node = currentNode.cameFromNode;  }
 path.Reverse();
 return path;
 }

 private int CalculateDistanceCost(PathNode a, PathNode
b) {  int xDistance = Mathf.Abs(a.x - b.x);
 int yDistance = Mathf.Abs(a.y - b.y);
 int remaining = Mathf.Abs(xDistance - yDistance);  return
MOVE_DIAGONAL_COST *
Mathf.Min(xDistance,  yDistance) +
MOVE_STRAIGHT_COST * remaining;  }

 private PathNode
GetLowestFCostNode(List<PathNode>  pathNodeList)
{
 PathNode lowestFCostNode = pathNodeList[0];  for (int i =
1; i < pathNodeList.Count; i++) {  if (pathNodeList[i].fCost
< lowestFCostNode.fCost) {  lowestFCostNode =
pathNodeList[i];
 }
 }
 return lowestFCostNode;
 }

 }
```



CHAPTER 6

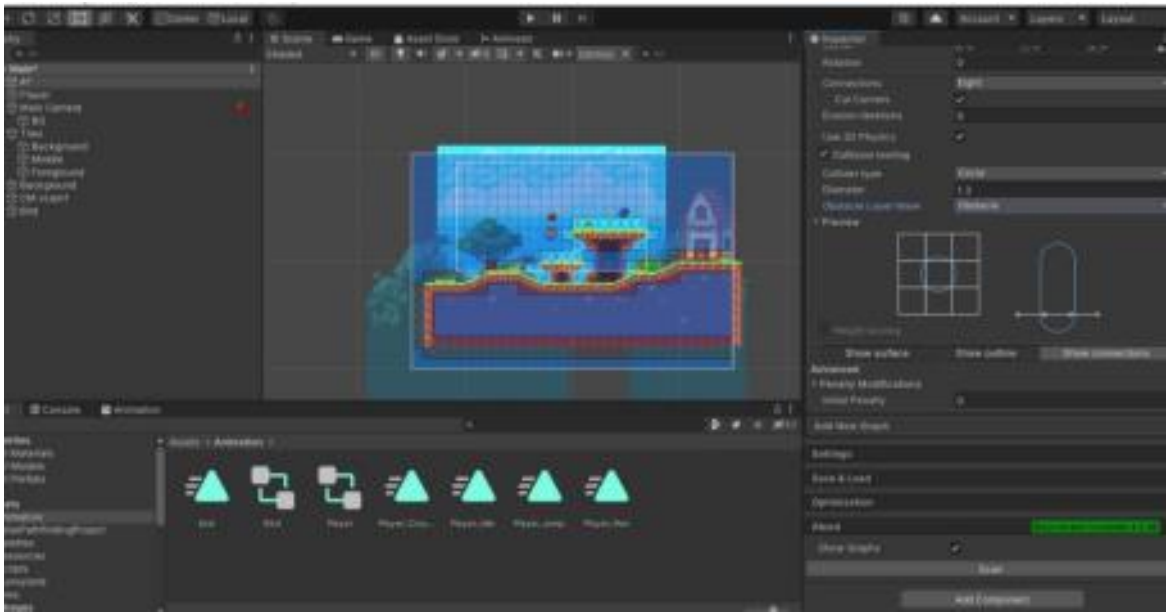
SCREENSHOTS AND RESULTS



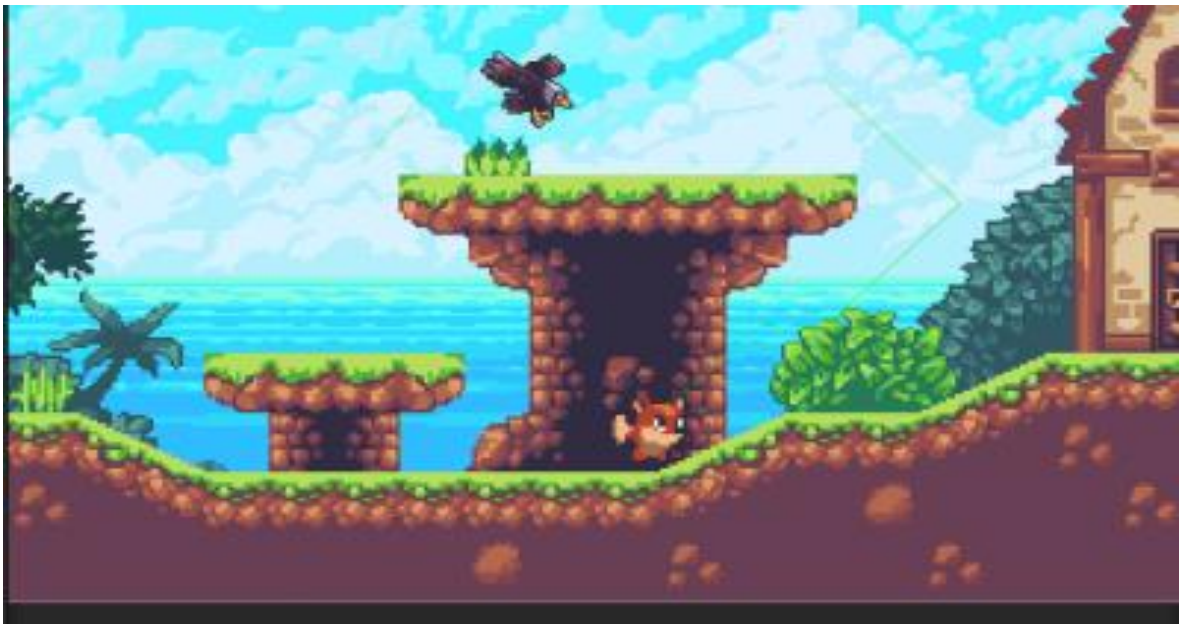
Sunny Land asset

Creating and animating the player character

Creating and animating the enemy bird AI character.



Detecting obstacles using inbuilt unity pathfinding tool. Red are obstacles and blue are areas which can be navigated



faintly visible green line which is the path being calculated by our AI agent.

CHAPTER 7

CONCLUSION AND FUTURE ENHANCEMENTS

A) Limitations of A* -

A* requires a large amount of CPU resources, if there are many nodes to search through as is the case in large maps which are becoming popular in the newer games. In sequential programs this may cause a slight delay in the game. This delay is compounded if A* is searching for paths for multiple AI agents and/or when the agent has to move from one side of the map to the other. This drain on CPU resources may cause the game to freeze until the optimal path is found. Game designers overcome these problems by tweaking the game so as to avoid these situations.

The inclusion of dynamic objects to the map is also a major problem when using A*. For example once a path has been calculated, if a dynamic object then blocks the path the agent would have no knowledge of this and would continue on as normal and walk straight into the object. Simply reapplying the A* algorithm every time a node is blocked would cause excessive drain on the CPU.

A key issue constraining the advancement of the games industry is its over reliance on A* for pathfinding. This has resulted in game designers getting around the associated dynamic limitations by tweaking their designs rather than developing new concepts and approaches to address the issues of a dynamic environment [Higgins02]. This tweaking often results in removing/reducing the number of dynamic objects in the environment and so limits the dynamic potential of the game.

B) Possible Solution -

A potential solution to this is to use neural networks or other machine learning techniques to learn pathfinding behaviours which would be applicable to realtime pathfinding.

C) Conclusion -

Thus we have studied the implementation of A* algorithm for path finding in games using Unity. We have also explored its limitations

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