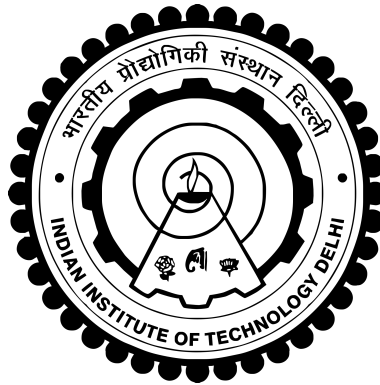


# **COP 290 Assignment 3**

## **Space Invaders**



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# 1 Objectives

Design a game which is :

- Multi-player on-line without a central server.
- Has a artificial intelligence component.
- Is an action game and not a simple board game.



# 2 Overall Design

The game which we will build is space invaders. It involves the player controlling a space ship and shooting down aliens. The aliens will fight back with bullets and missiles. The player has a limited number of lives and has to score the maximum in them.

1. The application would be programmed in C++.
2. The GUI part would involve OpenGL.
3. UDP sockets will be used for network data transfer.
4. POSIX threads will be used to run the network and back-end in parallel.
5. Inter thread synchronization would be done using mutex lock.

## 3 Sub Components

### 3.1 Back End

The back end has been divided into further sub components to facilitate the development process.

#### 3.1.1 Alien

This class contains all the information for an alien. The alien will be controlled by artificial intelligence. The level parameter stores the difficulty level which is the quality of AI. There are different types of aliens each with varied number of bullets fired per shot and the number of missiles it has.

Listing 1: Class Parameters for Alien

---

```
1 class Alien
2 {
3     private:
4         float XPos;           // X coordinate
5         float YPos;           // Y coordinate
6         float Angle;          // Orientation angle
7         Color ColorOfAlien;    // Color
8         int Level;             // AI difficulty level
9         int PresentLives;      // Lives left
10        int NumberBullets;      // Bullets fired per shot
11        int NumberMissiles;     // Number of missiles left
12        int AlienType;         // Type
13    };
```

---

#### 3.1.2 Ship

This contains the details for the space ship which are the location, orientation, score, player name etc. If AI has to be active on this player will be determined based on the parameters.

Listing 2: Class Parameters for Ship

---

```
1 class Ship
2 {
3     private:
4         float XPos;           // X coordinate
5         float YPos;           // Y coordinate
6         float Angle;          // Angle
7         std::string Name;      // Name of player
8         Color ColorOfShip;     // Color of ship
9         int Lives;             // Lives left
10        int Score;             // Score of player
```

```

11     int Multiplier;           // Multiplying factor
12     int Kills;               // No. of kills
13     int Id;                  // Player id
14     int NumberBullets;       // Bullets fired per shot
15     int NumberMissiles;      // Number of missiles left
16     int AILevel;             // Level of AI
17 };

```

---

### 3.1.3 Color

This is a helper class used for storing the color parameters of any object. It has 3 components lying in the range of 0 to 1 for R,G,B values.

Listing 3: Class Parameters for Color

```

1  class Color
2  {
3  private:
4      float R;                // Value of R component
5      float G;                // Value of G component
6      float B;                // Value of B component
7  };

```

---

### 3.1.4 Bullet

Contains all information about bullets and missiles. AI will be active on the missiles. Bullets will travel in straight lines. With each bullet a parameter will store the ship it was fired from so that the score of the player can be incremented appropriately.

Listing 4: Class Parameters for Bullet

```

1  class Bullet
2  {
3  private:
4      float XPos;              // X Coordinate
5      float YPos;              // Y Coordinate
6      float VelX;              // Velocity X
7      float VelY;              // Velocity Y
8      Color ColorOfBullet;     // Color
9      int ShipId;              // Id of ship fired from
10     bool TypeAI;              // If AI bullet
11     bool TypePlayer;          // Player type
12 };

```

---

### 3.1.5 Board

The entire information of game-play will be controlled from this. The graphics component will use this to generate the display. The network component will keep this in sync amongst all players.

Listing 5: Class Parameters for Board

---

```
1  class Board
2  {
3  private:
4      std::vector<Ship> VectorShips;           // All ships
5      std::vector<Bullet> VectorBullets;       // All bullets
6      std::vector<Alien> VectorAliens;         // All aliens
7      double DimensionPosX;                   // Dimensions + x
8      double DimensionPosY;                   // Dimensions + y
9      double DimensionNegX;                   // Dimensions - x
10     double DimensionNegY;                   // Dimensions - y
11 };
```

---

## 3.2 Artificial Intelligence

The Artificial Intelligence Component of the project will encompass 3 areas:

### 3.2.1 Aliens

The AI for Aliens will deal with:

1. Movement of Aliens to dodge Bullets and aim at the ships.
2. Shooting accuracy, frequency of shooting and speed of the aliens.
3. Strategies will be adopted by aliens to make life tough for the ships.

### 3.2.2 Ships

The AI for Ships will be a counterpart for the AI for the Aliens with similar features.

### 3.2.3 Missiles

The ships will have special potent missiles which can zone into the target. These will be limited in number. The design of the AI for these missiles includes accelerating in the direction of the target and starting to decelerate at the right point of time so that they reach the target exactly and dont overshoot.

### **3.2.4 Strategy**

The strategy of the alien/ship will be based on the concept of finite state machines where the AI will transition between particular states of operation, such as attacking, dodging and fleeing, based on the situation.

### **3.2.5 Difficulty**

1. Against aliens: The Alien class has an object level based on which the efficiency of the aliens will be decided using an equation with parameters for accuracy, speed and frequency, and different modes of operation have different coefficients for the factors.
2. Against opponents: The ship class has an object called AI level which decides the level of efficiency of the ship. Again, this is decided by a complex equation with parameters for the same and different modes of operation.

### **3.2.6 Learning for AI**

This will include making different AI players play against each other to ascertain the defining characteristics of a good AI. They will be made to play against different aliens to ascertain the defining characteristics of efficient aliens.

### **3.2.7 Incorporation**

The AI files will be designed for Entity Pull systems where the AI system is called when a new frame is rendered.

## **3.3 Graphics**

1. To make the graphics we will use OpenGL primarily. Each of the subcomponents like aliens, ships etc will be made in blender and the object files will be generated. Then these object files would be rendered by OpenGL to generate the display.
2. The frame rate will be set to 30 fps. Whenever a new frame is rendered, the update functions for AI will be called. The user input will also get incorporated accordingly.
3. GUI effects will be added when bullets shoot down aliens or ships. This will provide a richer and fuller user experience.

## **3.4 Network Part**

We will use the User Datagram Protocol (UDP) to design and implement the network aspect of the assignment. It is a communications protocol that offers a limited amount of service when messages are exchanged between computers in a

network that uses the Internet Protocol (IP). UDP uses a simple connectionless transmission model with a minimum of protocol mechanism. It has no hand-shaking dialogs, and thus exposes any unreliability of the underlying network protocol to the user's program. There is no guarantee of delivery, ordering, or duplicate protection. UDP provides checksums for data integrity, and port numbers for addressing different functions at the source and destination of the datagram. UDP is suitable for purposes where error checking and correction is either not necessary or is performed in the application, avoiding the overhead of such processing at the network interface level.

### 3.4.1 Why UDP?

Our application is a real-time multi-player video game, thus we need fast transfer of data. As stated above, UDP can be fast but unreliable. Even if some of the packets are lost due to unreliability of UDP, it won't affect much. Things change so fast (i.e. player movement, bullets firing) in the game that it doesn't make sense to resend a lost packet as it will contain old information.

### 3.4.2 Basic Network Design

Our network will work on the basis of following points

- Each player will have two basic threads.
- One thread for receiving data from other players.
- Second thread for sending data to other players.

**We shall be sending data** (i.e. player position, AI components data etc) **as soon a frame is rendered**. This means that we will send almost 30-60 messages every second and hence the use of UDP is justified.

### 3.4.3 Network Outages

In the event of a network outages, we shall replace control of the ship of the lost player with AI of same level. The level of AI would be calculated on the basis of the score just before the player was lost. Once the player reconnects, he will automatically gain control of his lost ship.

### 3.4.4 Peer-to-Peer

Each of the player in the game would be exchanging its data with each and every other player. Thus we shall implement a peer-to-peer (P2P) connection. To control AI components of the game, we shall be using the concept of a "temporary server" or a "virtual server". A randomly chosen person will be chosen as the "temporary server". This player will act as the AI of the game and will send messages to all the other players accordingly. If a player other than this one disconnects, no change is required. If this player disconnects, another active player will be chosen to act as the "temporary server".



### 3.4.5 Basic UDP Functions

- Socket Creation

Listing 6: socket()

---

```
1 socket(AF_INET, SOCK_DGRAM, 0)
2 //AF_INET for Pv4 Internet protocol
3 //UDP uses SOCK_DGRAM
4 //0 is the protocol
```

---

- When a socket is created with socket(), it exists in a name space (address family) but has no address assigned to it. bind() assigns the address specified by addr to the socket referred to by the file descriptor sockfd. addrlen specifies the size, in bytes, of the address structure pointed to by addr. Traditionally, this operation is called “assigning a name to a socket”.

Listing 7: bind()

---

```
1 bind(fd, (struct sockaddr *)&myaddr, sizeof(myaddr))
2 //fd is the sockfd
3 //myaddr is the address of the player
```

---

- Receiving data

Listing 8: recvfrom()

---

```
1 recvfrom(fd, buf, BUFSIZE, 0, (struct sockaddr *)&remaddr, &addrlen)
2 //fd is the sockfd
3 //buf is array of characters in which the message will be received
4 //remaddr is the address of the connection player
```

---

- Sending data

Listing 9: sendto()

---

```
1 sendto(fd, buf, strlen(buf), 0, (struct sockaddr *)&remaddr, addrlen)
2 //fd is the sockfd
3 //buf is array of characters which contains the data to be sent
4 //remaddr is the address of the sending player
```

---

## 4 Interaction amongst Sub Components

### 4.1 Back-end and UI

The GUI will use the data structures directly. The “Board” class will be available to generate the display on the screen. The user inputs from keyboard and mouse will be used to generate changes in the class object.

## 4.2 Back-end and Network

The back end and network components will run on separate threads. Whenever a frame is rendered the network thread for sending will become active. At the same time all the received messages will get processed and applied in the stored parameters. Locks will be used on the message queue to ensure proper synchronization.

## 5 Testing Of Components

### 5.1 General Unit Tests

Listing 10: Class Parameters for Test

---

```
1 class Test
2 {
3 private:
4     bool verbose;           //If test is to be conducted
5     std::string description; //String description of the test
6     bool isPass;           //Boolean if the test has passed
7     void PrintPassFail(bool); //Prints the status of the test
8 };
```

---

We will use the aforementioned class “Test” to perform unit tests on the different files created. This will ensure that all the functions work correctly against some test cases.

### 5.2 Graphics

To test the graphics component, we will create aliens and ships at chosen positions. The positions should change appropriately based on user inputs. Bullets should also be fired from the correct positions. When a bullet hits an alien or a ship, proper GUI effects will be added.

### 5.3 Artificial Intelligence

Extensive testing of the AI components will include

- Making AI players of different levels play against each other to make sure the higher level AI players play better. Making them play against different aliens will ascertain that higher level aliens are difficult to beat.
- Performance of AI players against real players will also be tested to determine the ideal AI for an interesting competition.

## 5.4 Network Component

Testing of network will be divided into two stages.

- In the first stage, we shall test the basic transfer of data. We shall be about 100 dummy messages from one player to another using a simple for loop. The receiver will record the number of messages received and thus we can determine the percentage of packets dropped.
- In the second stage, we shall be test the shifting of the “temporary server” from one player to another when the player gets disconnected. In this case, the “temporary server” shall be sending dummy messages. We shall connect about three players. After the connection is established, we shall close the application of the “temporary server”. One of the other two must become the “temporary server” and sending of dummy message should be continued.

## 5.5 Overall Testing

For overall testing of the game, we will play the game with as many players as possible and verify the smooth functioning of AI and network component. The network for some clients will be shut down suddenly to check if the transitions for the AI and others are smooth.

# 6 Extra Features

## 6.1 Competitive Multi-player Mode

In this multi-player mode, the players will be fighting each other. They will try to shoot each other down. Aliens will not be present in this mode. AI players will be present in this.

## 6.2 3D Game-play

The game will be taken to 3D in which the aliens and ships can be viewed in a 3D perspective. The camera position will be adjusted by the user based on input from mouse.

## 6.3 Sound Effects

Sound effects will be added for the entire game-play. When bullets are fired or some shoot down takes place, appropriate sounds will be played.

## 6.4 Replacement of Player by AI

In case of network failures, the player whose network has gone down will get replaced by an AI player of the same level as the player was. This will ensure

completely seamless transition in case of network outages. Once the network comes back on, the player will replace the AI control.