Acs pada approach

Projectile Motion

Definition: Projectile motion is a type of motion experienced by an object (called a projectile) that is projected into the air and affected only by gravity (assuming no air resistance). The motion is analyzed in two dimensions: horizontal and vertical.

Key Characteristics:

- **Components**: It involves both horizontal and vertical components of motion.
    - **Horizontal Motion**: Constant velocity, no acceleration (in the absence of air resistance).
    - **Vertical Motion**: Accelerated motion due to gravity.
- **Path**: The trajectory of the projectile is a parabola, which is a consequence of the combined horizontal motion at constant speed and vertical motion under constant acceleration.

Equations:

- Horizontal Distance: $x(t) = v_0 \cos(\theta) \cdot t$
- Vertical Position: $y(t) = v_0 \sin(\theta) \cdot t - \frac{1}{2} g t^2$
- Trajectory Equation: $y = x \tan(\theta) - \frac{g x^2}{2 v_0^2 \cos^2(\theta)}$

The concept of a "drop mechanism" for a plane using a "projectile approach" typically involves understanding how an object (such as a bomb or cargo) is released from an aircraft and follows a projectile-like trajectory under the influence of gravity. This is essentially analyzing how an item behaves once it's dropped from a moving plane and how to predict its path and impact point.

1. Understanding the Problem

When an object is dropped from a moving plane, it initially shares the horizontal velocity of the plane. Once released, it is subject to gravity and will follow a projectile trajectory. The goal is to determine where the object will land relative to the point of release.

2. Key Parameters

To analyze the drop, you need to know:

- **Initial Horizontal Velocity (vx0v_{x0}vx0)**: This is the horizontal velocity of the plane at the moment of release.
- **Vertical Velocity (vy0v_{y0}vy0)**: For a simple drop, this is typically zero if the object is released without additional vertical motion.
- **Altitude (hhh)**: The height from which the object is dropped.

- **Acceleration Due to Gravity (ggg)**: Typically 9.8 m/s29.8 \, \text{m/s}^29.8m/s2.

3. Time of Fall

To find out how long the object will be in the air (time of flight), use the vertical motion equation:

$$t = \sqrt{\frac{2h}{g}}$$

Here, hhh is the altitude from which the object is dropped.

4. Horizontal Distance (Range)

The horizontal distance (range) the object will travel is determined by its horizontal velocity and the time it is in the air:

$$d = v_{x0} \cdot t$$

5. Calculating Impact Point

1. **Time of Flight**: Calculate the time ttt it takes for the object to fall from the plane to the ground.
2. **Horizontal Displacement**: Use the horizontal velocity and time of flight to determine how far from the drop point the object will land.

Suppose an aircraft is flying horizontally at an altitude of 500 m500 \, \text{m}500m and a horizontal speed of 200 m/s200 \, \text{m/s}200m/s. To find where an object will land if dropped:

1. 1. **Calculate Time of Flight:**

   $$t = \sqrt{\frac{2 \times 500}{9.8}} \approx \sqrt{101.02} \approx 10.05\,\mathrm{s}$$

   2. **Calculate Horizontal Distance:**

   $$d = 200\,\mathrm{m/s} \times 10.05\,\mathrm{s} \approx 2010\,\mathrm{m}$$

Forces to be considered

1.Gravity :Fg acts downwards and is equal to mg

2.**Drag Force fd**: Opposes the motion

$$F_d = \frac{1}{2}\rho v^2 C_d A$$

where:

- ρ = air density
- v = velocity of the object
- C_d = drag coefficient
- A = cross-sectional area

3.**Wind and Crosswinds**:
Headwind/Tailwind: Directly affects horizontal velocity.
Crosswind: Affects the trajectory laterally.

Equation of motion with all forces:

1.**Horizontal Motion**

For an object in the presence of wind and drag:

$$m\frac{dv_x}{dt} = -\frac{1}{2}\rho v_x^2 C_d A + F_{\text{wind,x}}$$

$$\frac{dx}{dt} = v_x$$

- v_x = horizontal component of velocity
- $F_{\text{wind,x}}$ = force due to wind in the x-direction (can be calculated as $F_{\text{wind,x}} = m \cdot w_x$, where w_x is the wind speed in the x-direction)

2. **Vertical Motion**

For an object subject to gravity and drag:

$$m\frac{dv_y}{dt} = -mg - \frac{1}{2}\rho v_y^2 C_d A + F_{\text{wind,y}}$$

$$\frac{dy}{dt} = v_y$$

- v_y = vertical component of velocity
- $F_{\text{wind,y}}$ = force due to wind in the y-direction (if there is any vertical component of wind, which is often minimal compared to the effect of gravity and drag)

Autonomous Approach

An autonomous RC aircraft approach involves a combination of sensors, navigation algorithms, and control systems to manage its flight path without human intervention. The system needs to handle.

Important parts for approach

Navigation: we need to determine the starting and the ending points for our systems.

Path Planning: Creating a flight path that meets mission objectives and takes in note if the pada is travelling in the correct direction or not.

Control Systems: Adjusting the pada's flight controls such that they follow this part and can reach their objective even if faced by some unexpected conditions like cross winds.

For a better approach we need to divide the working of our systems into stages

1) Before plane goes on runway :-

   During this period the aircrafts system needs to be checked and verified to ensure that the system is working properly. Incase of any issues we need to solve it.

2) Before take-off :-

During this we need to keep the systems running such that the control surfaces are being used to provide enough lift force to generate lift for the aircraft.

3) During flight/cruise :-

During this the PADA's control must be off and PA should be at enough height to drop the PADA as per requirements. The PA should go into a designated zone which will be the most efficient and effective for PADA landing.

4) Before detachment :-

Just before the detachment of PADA its system must be turned this is done so as to save power and the PADA must be released from the PA only after it gets the heading.

This is done so because the time of flight of PADA is not long, maybe around 15 seconds hence, it is important to get a heading before detachment.

5) After detachment :-

This is the most important phase for the PADA, during this phase it is important for the PADA to get the heading.

If the PADA needs to detect a zone it should be done before detachment if possible.

After the PADA is detached it need to follow a path such that it reaches there and lands.

To keep a check on if the PADA is following the pathway we can create waypoints by making the area in 2d grid and assign coordinates which it need to pass though at what altitude and speed.

This will help the autonomous control the speed of PADA incase if we need more thrust than necessary.

6) Before Landing :-

During this phase it is important to control the height and speed of PADA as it can affect the landing of the PADA.