MTRN3500
Computing Applications in Mechatronics Systems

Developing a Flight Controller for a Quad-copter

T3 - 2020

Aim

- To logically analyze a complex system and develop a sophisticated software solution.
- The chosen system is an ordinary quad-copter operating in X configuration.
- Generally, these systems have non-linearities. However, in stable horizontal flying the non-linearities are minimal.

Approach

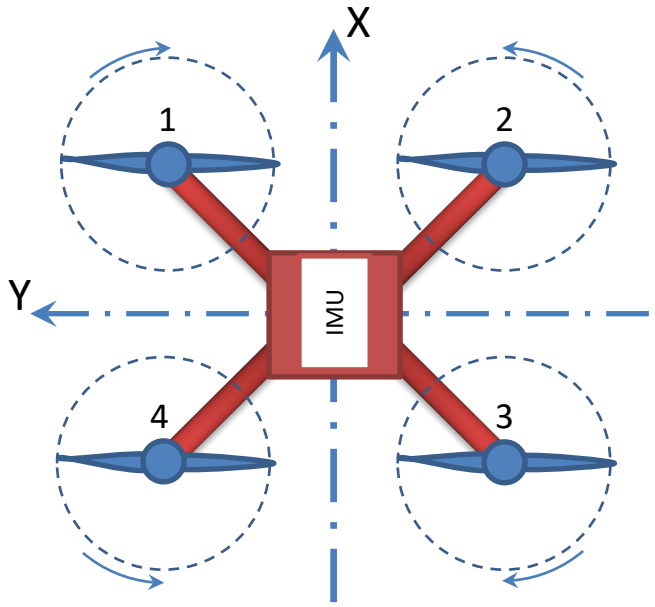
- Develop a complete schematic diagram incorporating all elements required.
- Breakdown the schematic to logical software units
- Develop classes for the logical units
- Develop the flight controller class

System Specifications

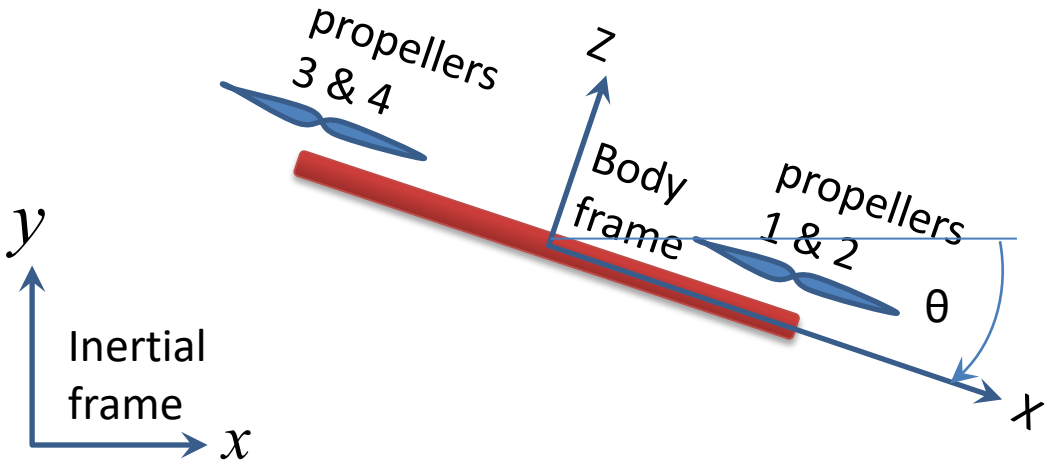
- System – quadcopter
- Controls required (attitude control only)
  - Pitch control
  - Roll control
  - Yaw control
- Controls required (position)
  - Heave rate control -> vertical position
- Sensing required
  - Gyro rates (roll, pitch and yaw rates in rad/sec).
  - Attitude sensing (roll, pitch and yaw angles in rad).
- Actuation
  - Speed control of four rotors
- Commands
  - From a remote transmitter

Red – Roll Command
Green – Pitch Command
Yellow – Yaw rate command
Purple – Heave rate command

Configuration

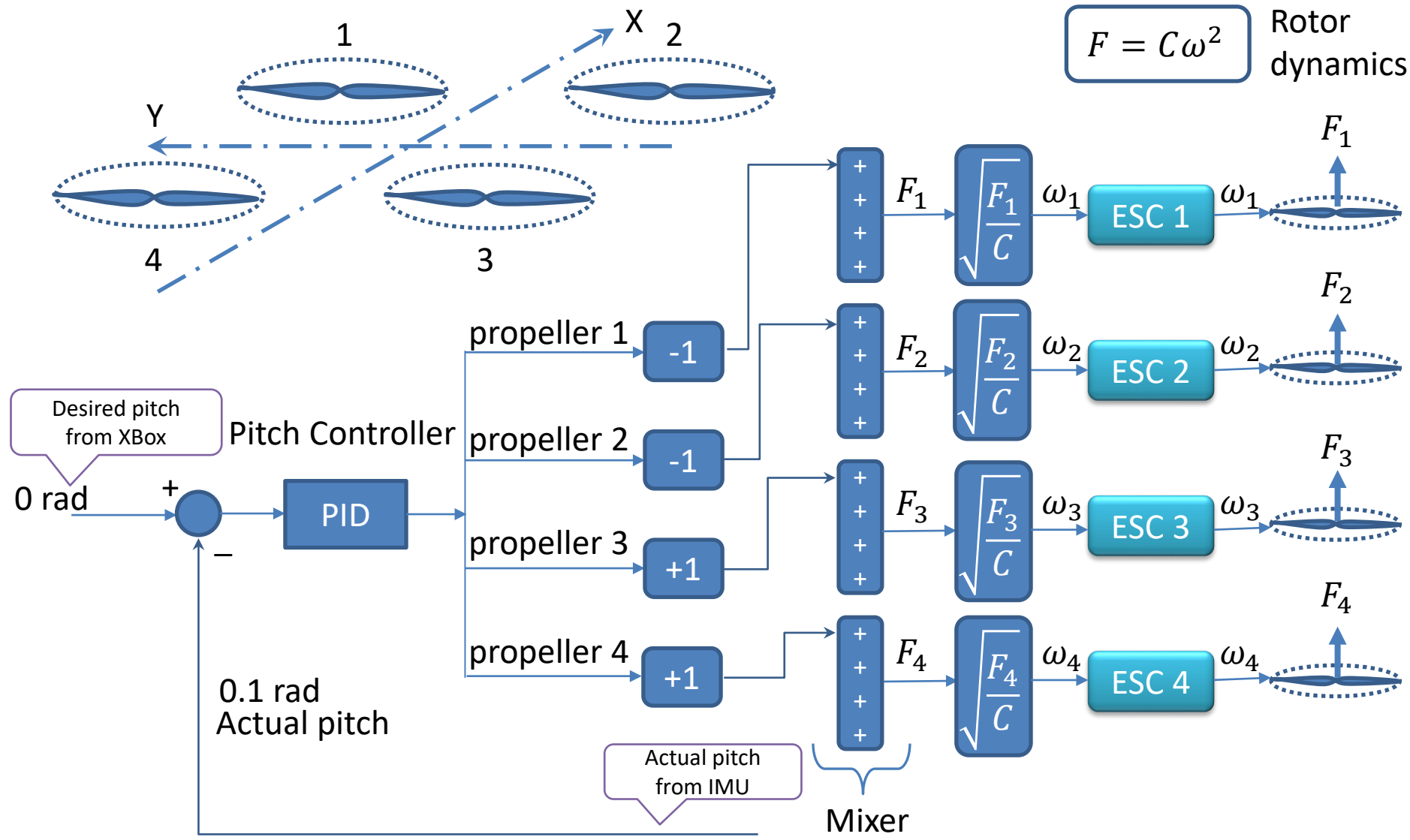


- X- configuration
- Counter rotating propellers
- X is the forward direction
- Z is vertically up
- Propellers are numbered from 1 – 4
- An IMU at the centre of the copter measures the attitude and gyro rates

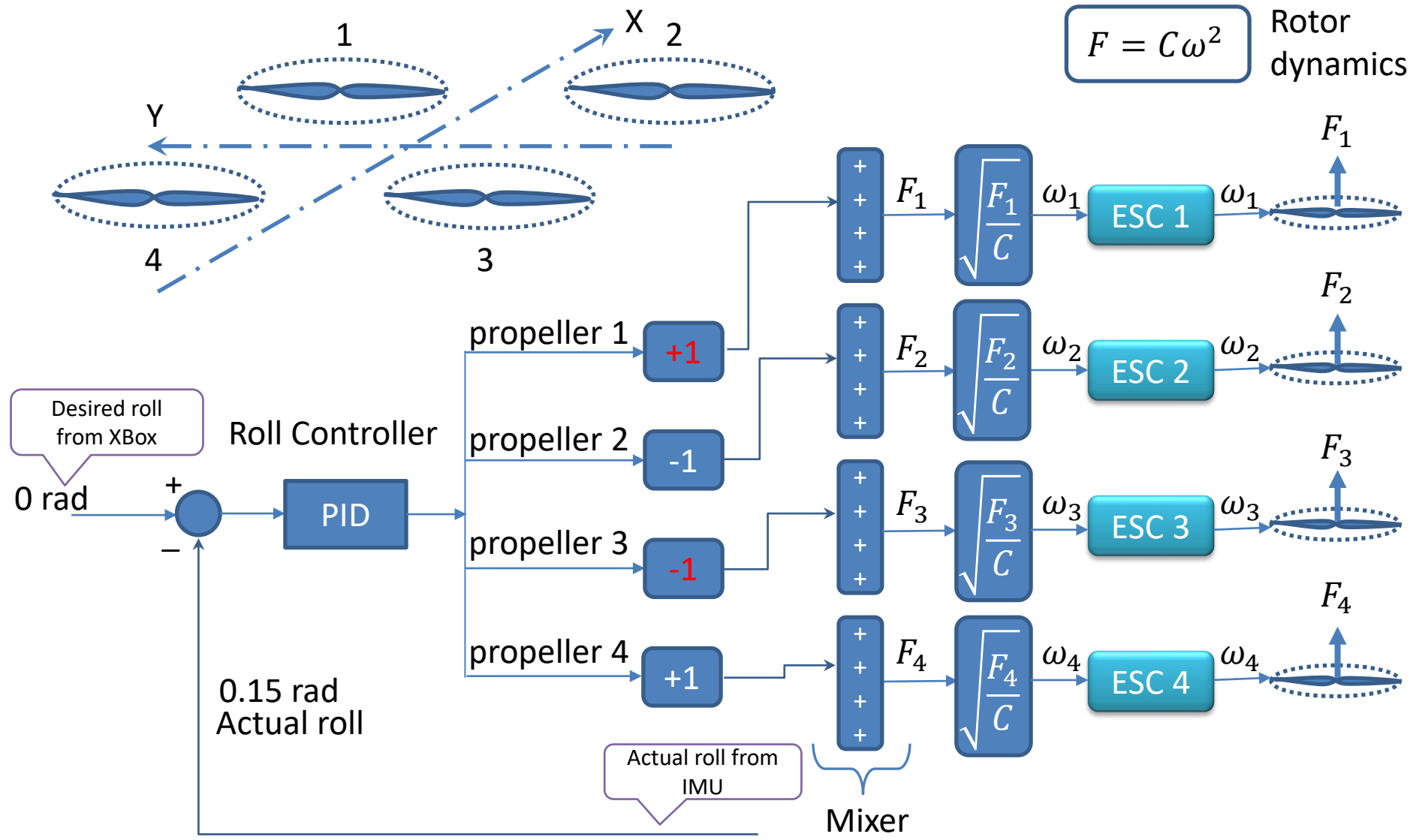


- A positive pitch angle θ will make the quadcopter move forward
- A positive roll angle φ will make the quadcopter move rightwards.
- A positive yaw angle ψ will rotate the quadcopter in counter clockwise direction.

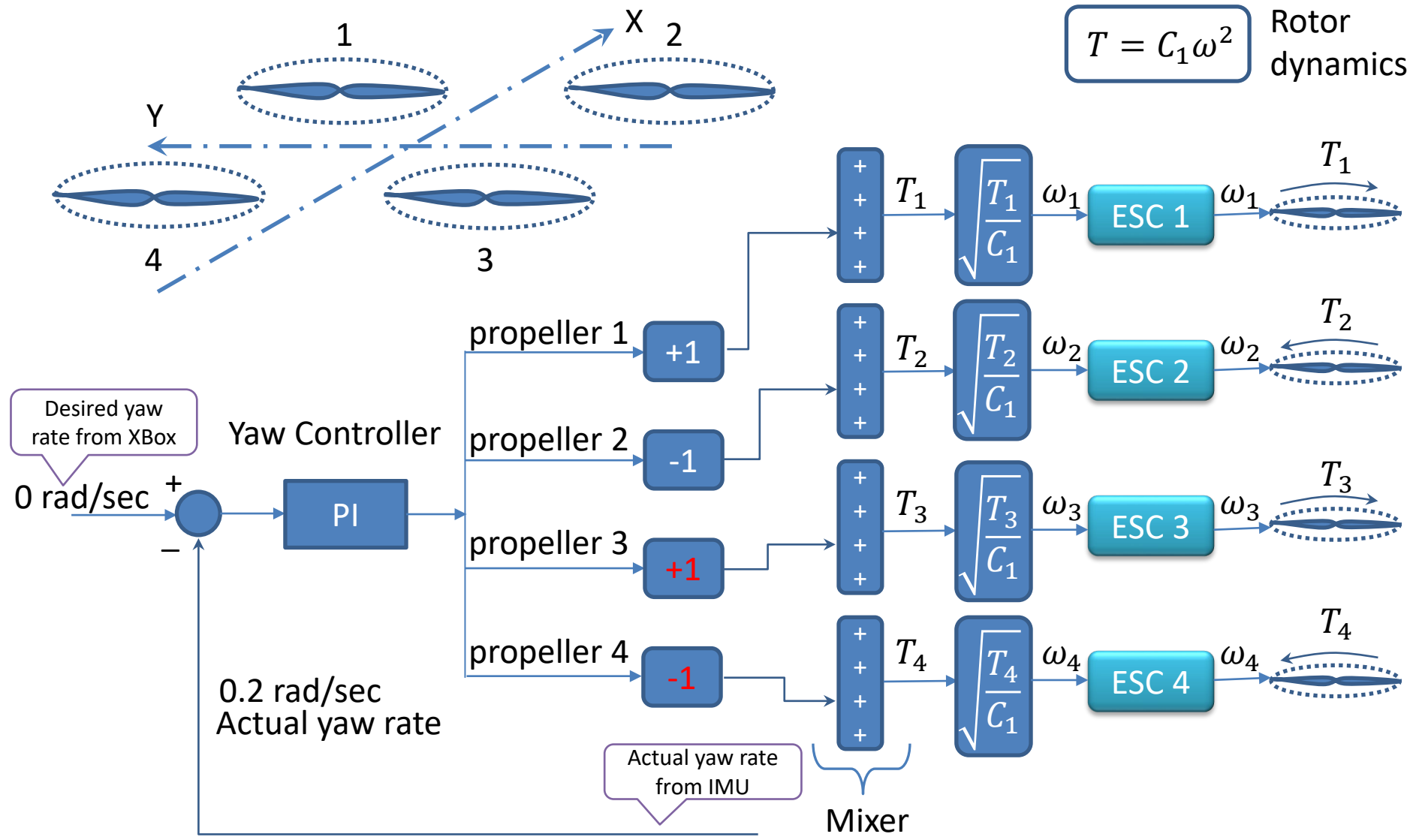
Pitch Control



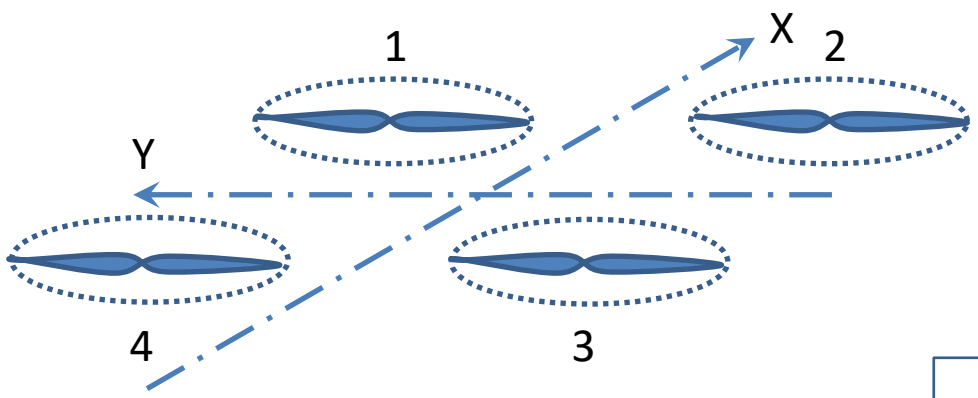
Roll Control



Yaw Rate Controller



Heave Rate Control



$F = C\omega^2$

Rotor dynamics

Desired heave rate from XBox

1 m/s

Heave Gain

K

propeller 1

propeller 2

propeller 3

propeller 4

+1

+1

+1

+1

F_1 F_2 F_3 F_4

$\sqrt{\frac{F_1}{C}}$ $\sqrt{\frac{F_2}{C}}$ $\sqrt{\frac{F_3}{C}}$ $\sqrt{\frac{F_4}{C}}$

ω_1 ω_2 ω_3 ω_4

ESC 1

ESC 2

ESC 3

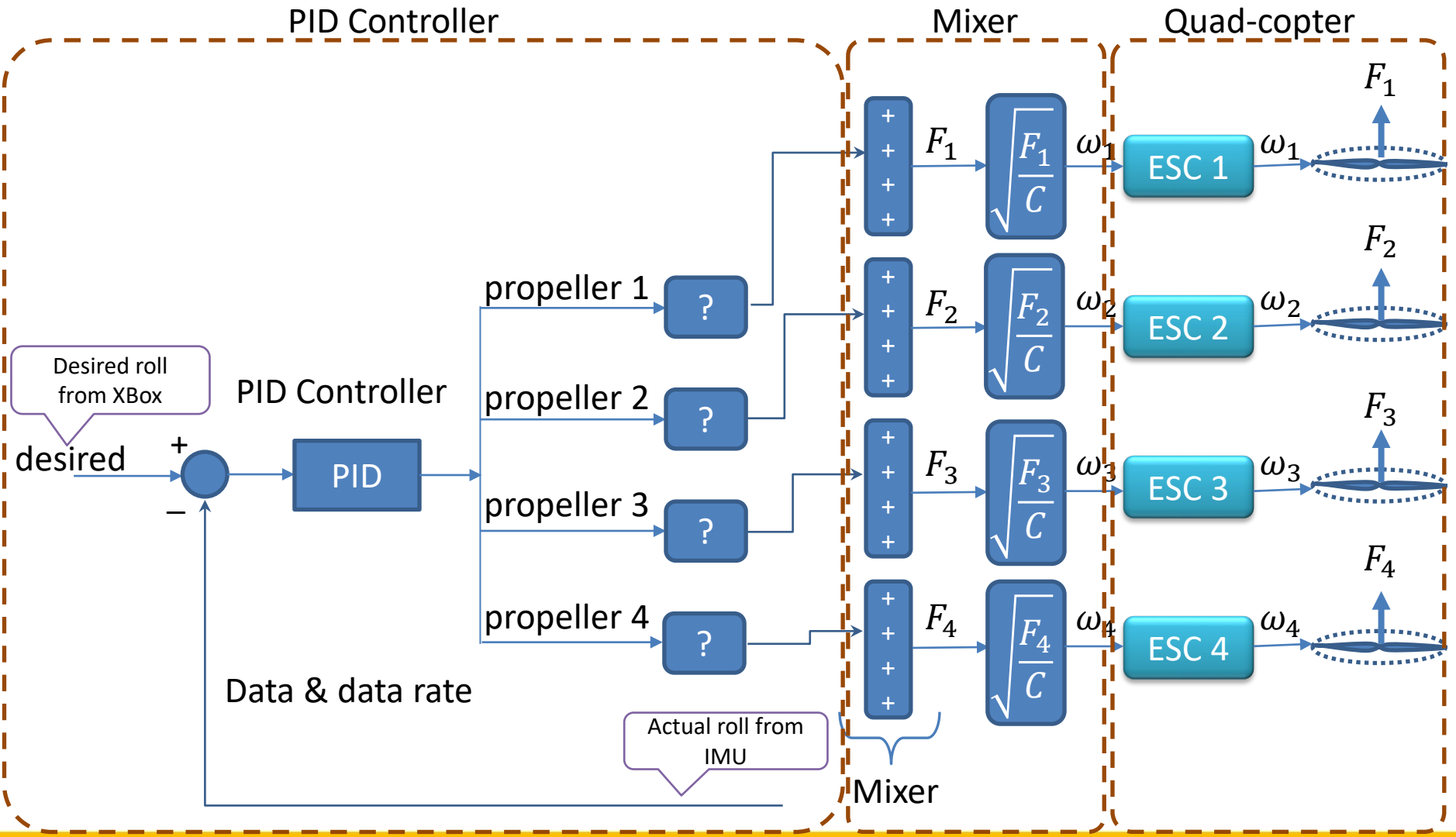
ESC 4

ω_1 ω_2 ω_3 ω_4

F_1 F_2 F_3 F_4

Mixer

Flight Controller



Let us Look at Some Software