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# Flight Control of a UAV Using Fuzzy Gain–Scheduled PID

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# Content



- Introduction
- Fuzzy Logic Overview
- Pioneer UAV
- Fuzzy Logic Structure
- Table of Rules
- Airspeed, Altitude and Heading Responses
- Conclusion

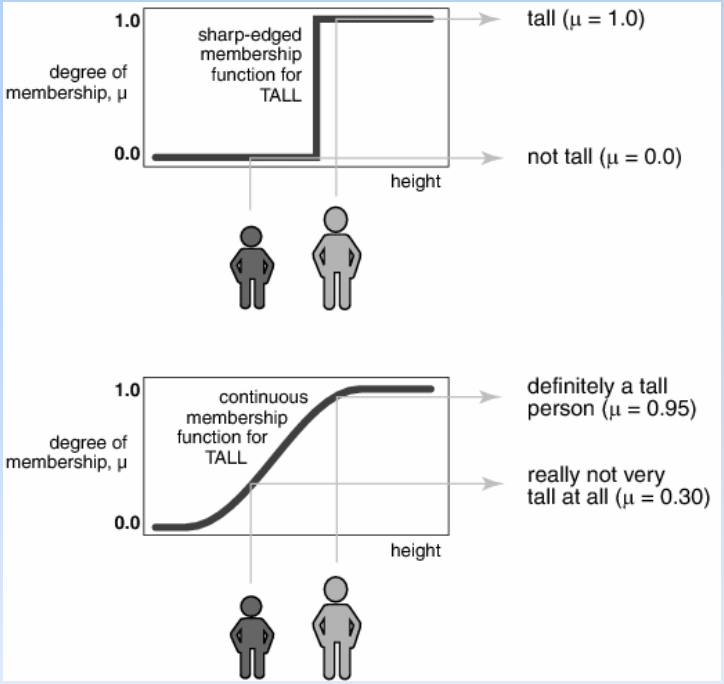
# Introduction

- Since the first flight of human being took place in the history, unmanned aerial vehicles (UAV) have been the focal point of aviation.
- Today UAVs have many applications fields such as remote inspection and monitoring, search operations, spy work, rescue and surveillance.
- In this work, the design of airspeed, altitude and heading controllers for Pioneer Unmanned Aerial Vehicle (UAV) aircraft is studied.
- A performance comparison between PID and Fuzzy-PID controllers designed for airspeed, altitude and heading are made.

# Fuzzy Logic Overview

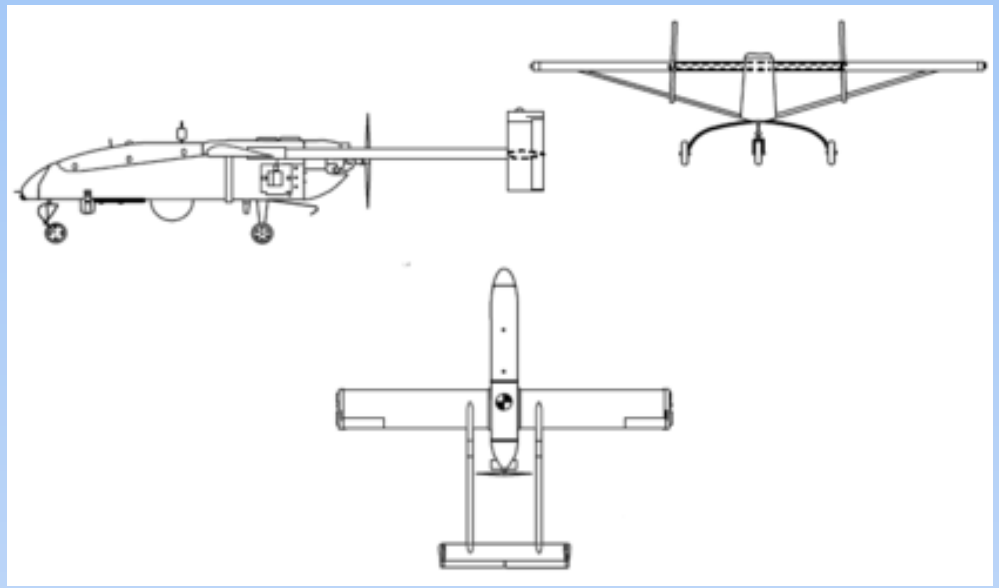


- Fuzzy Logic was developed in the seventies by Lotfi A. Zadeh, a professor at the University of California.
- Recently, fuzzy logic control has emerged as one of the most active and promising fields in the application of fuzzy set theory.
- There are now many technological products employing fuzzy logic, ranging from washing machines to high-speed trains.



# Pioneer UAV

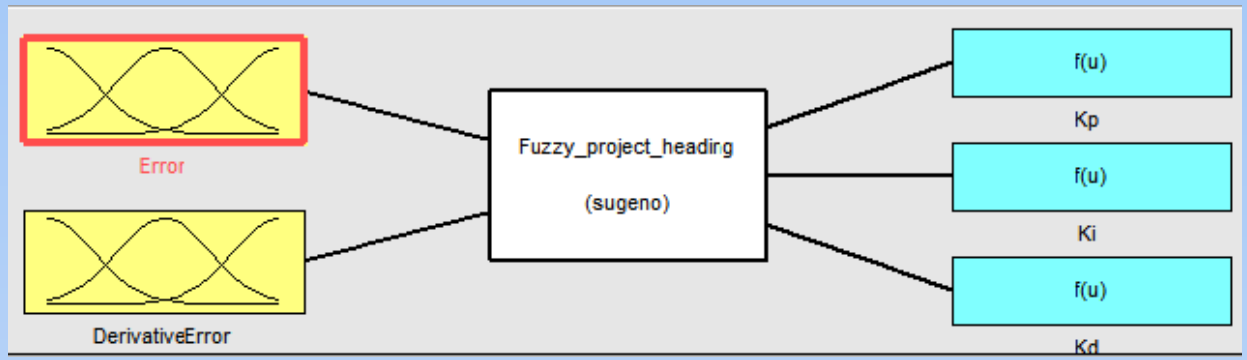


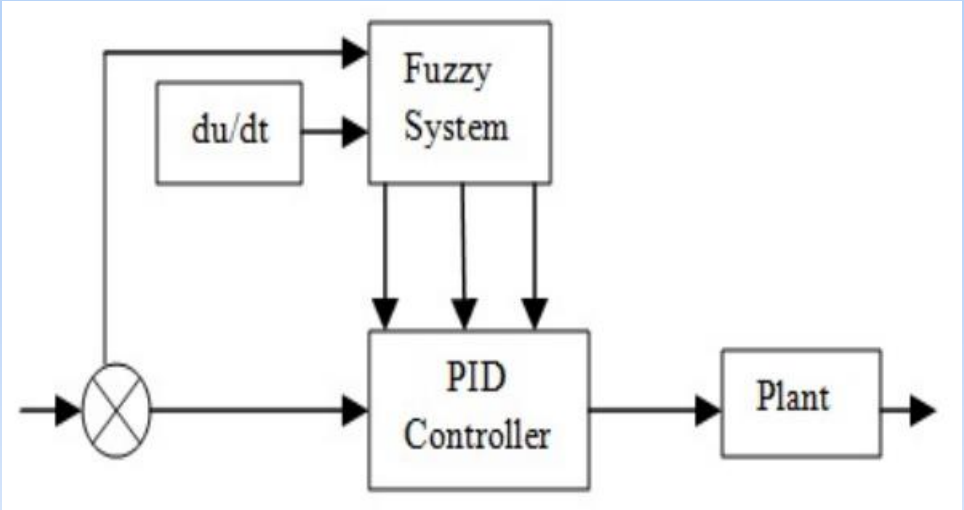


- Length: 14 feet (4 m)
- Height: 3.3 feet (1.0 m)
- Weight: 205 pounds (452 kilograms)
- Wingspan: 16.9 feet (5.2 m)
- Speed: 110 knots (200 km/h)
- Range: five hours at 100 nautical miles (185 kilometers )

# Fuzzy Logic Structure





# Table of Rules

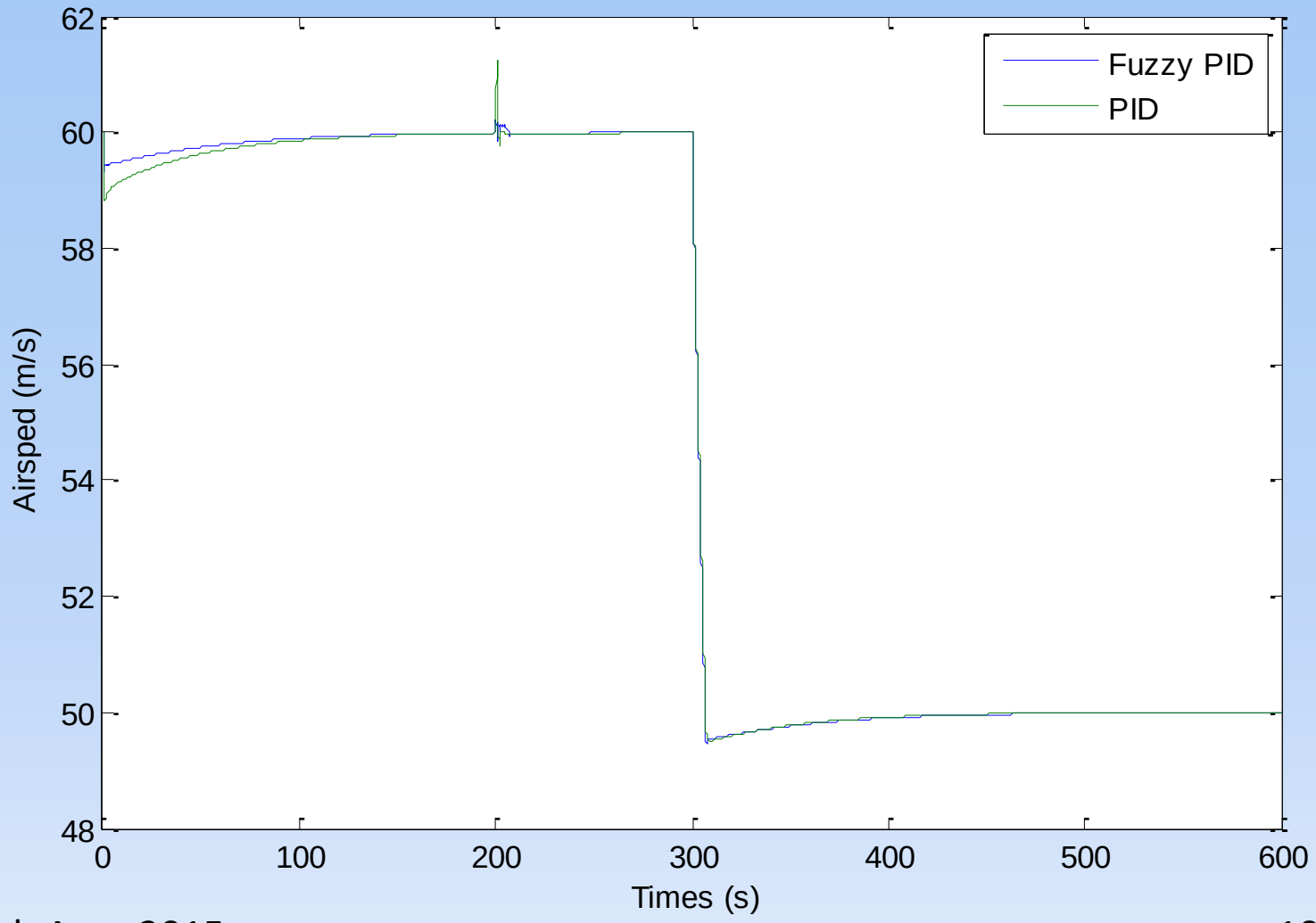


- When |e| is bigger value, Kp should be bigger, Kd should be smaller for better tracking performance and the Ki should be set to zero for avoiding integral saturation and heavier overshoot.
- When |e| and |ec| are middle value, neither Kp, Ki and Kd is too large for slight overshoot. Ki should be smaller while Kp and Kd should be moderate for rapid response.
- When the |e| is smaller value, both Kp and Ki should be increased for better steady performance .Kd should be moderate for avoiding oscillation around the corresponding static value.

| $(U_p, U_i, U_d)$ | | $\lvert de(t)\rvert$ | | | | |
|---|---|---|---|---|---|---|
| | | Z | VS | S | M | B |
| $\lvert e(t)\rvert$ | Z | (VS,B,M) | (VS,B,M) | (Z,B,M) | (Z,B,B) | (Z,B,B) |
| | VS | (VS,B,S) | (VS,B,M) | (VS,B,M) | (Z,M,M) | (Z,M,B) |
| | S | (S,M,VS) | (S,M,VS) | (S,M,VS) | (VS,S,S) | (VS,S,S) |
| | M | (M,Z,Z) | (M,Z,Z) | (M,VS,VS) | (S,VS,VS) | (S,VS,VS) |
| | B | (B,Z,Z) | (B,Z,Z) | (B,Z,Z) | (B,Z,Z) | (M,Z,Z) |

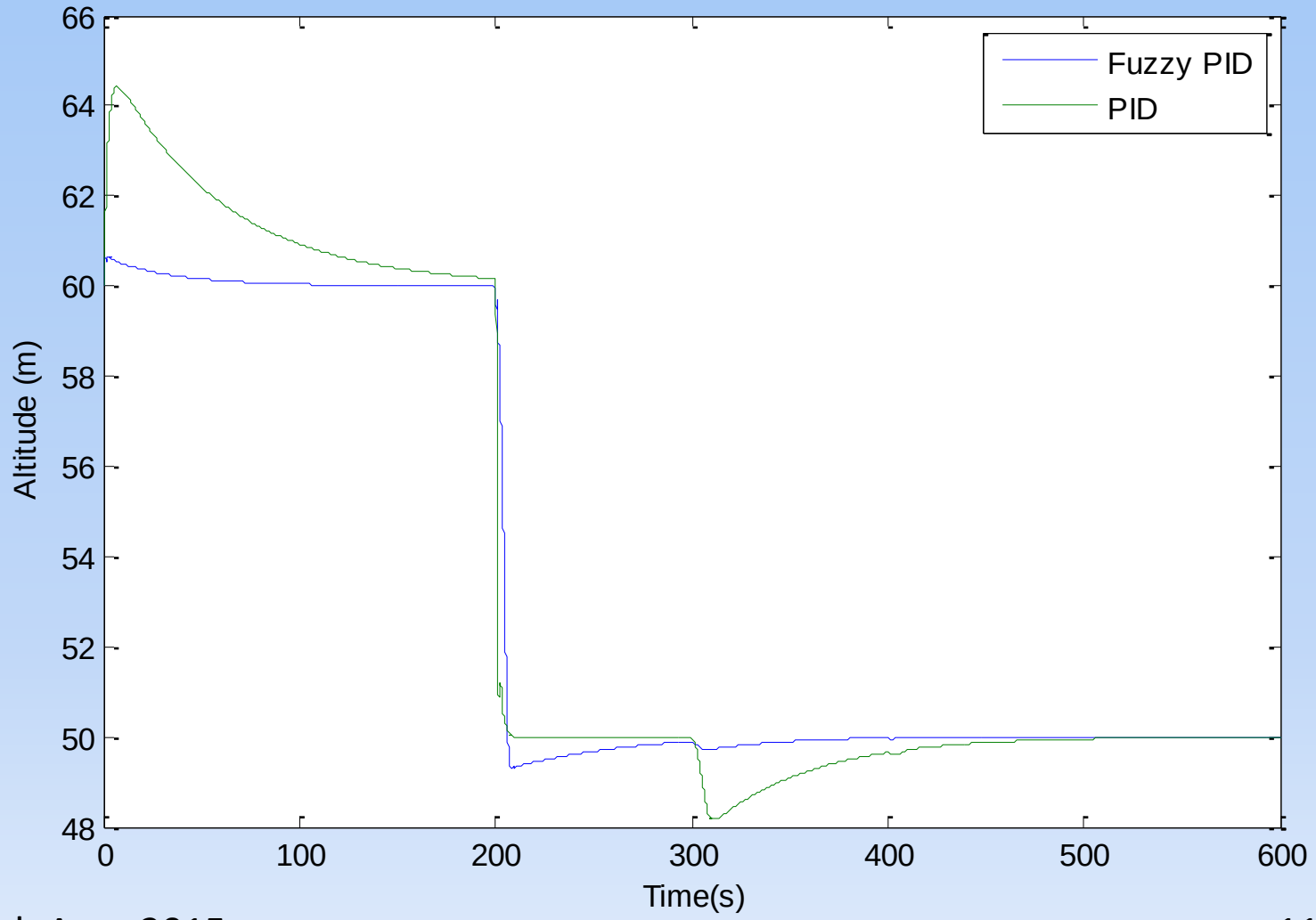
# Airspeed Response





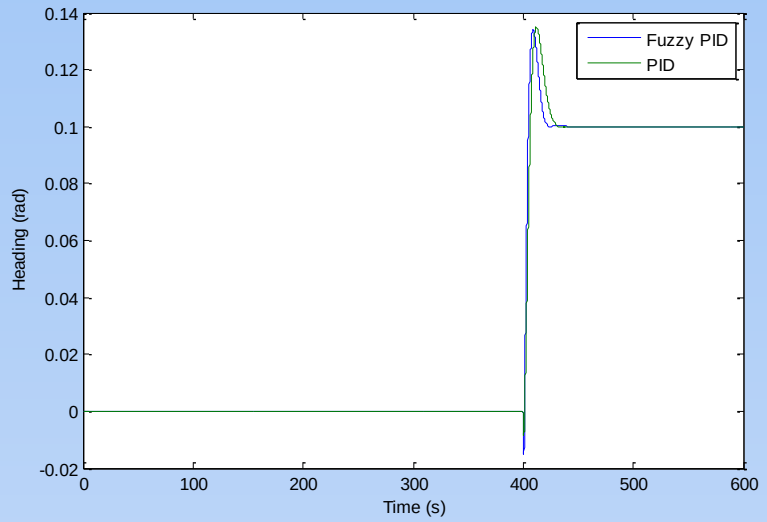
# Altitude Response

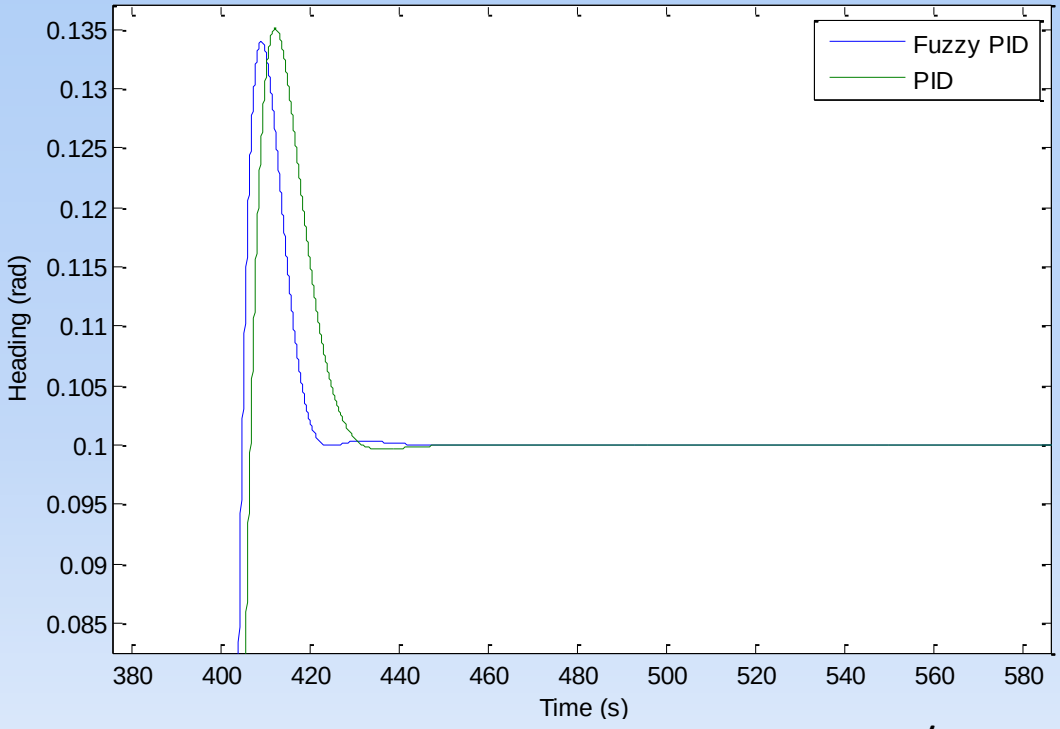




# Heading Response





# Conclusion



- In this study a fuzzy gain scheduled PID controller is designed and implemented to an UAV autopilot system in SIMULINK environment.
- The control of airspeed, altitude and heading parameters of UAV is performed using both PID and Fuzzy-PID.
- Results show that changing controller gains dynamically gives a better performance than fixed gain values.
- It should be noted that these results can be improved with a better tuning of the fuzzy logic parameters.

# THANK YOU FOR YOUR ATTENTION