

# CURRENT PROJECTS IN FUZZY CONTROL

by

Michio Sugeno  
Tokyo Institute of Technology

Fuzzy Logic Workshop  
14 November 1990

N 93-31442

53-67  
163077  
P-13

# Projects of Helicopter Flight Control

- o Radio Control by Oral Instructions  
(1989 - 1993)

Tokyo Institute of Technology  
supported by Science and  
Technology Agency

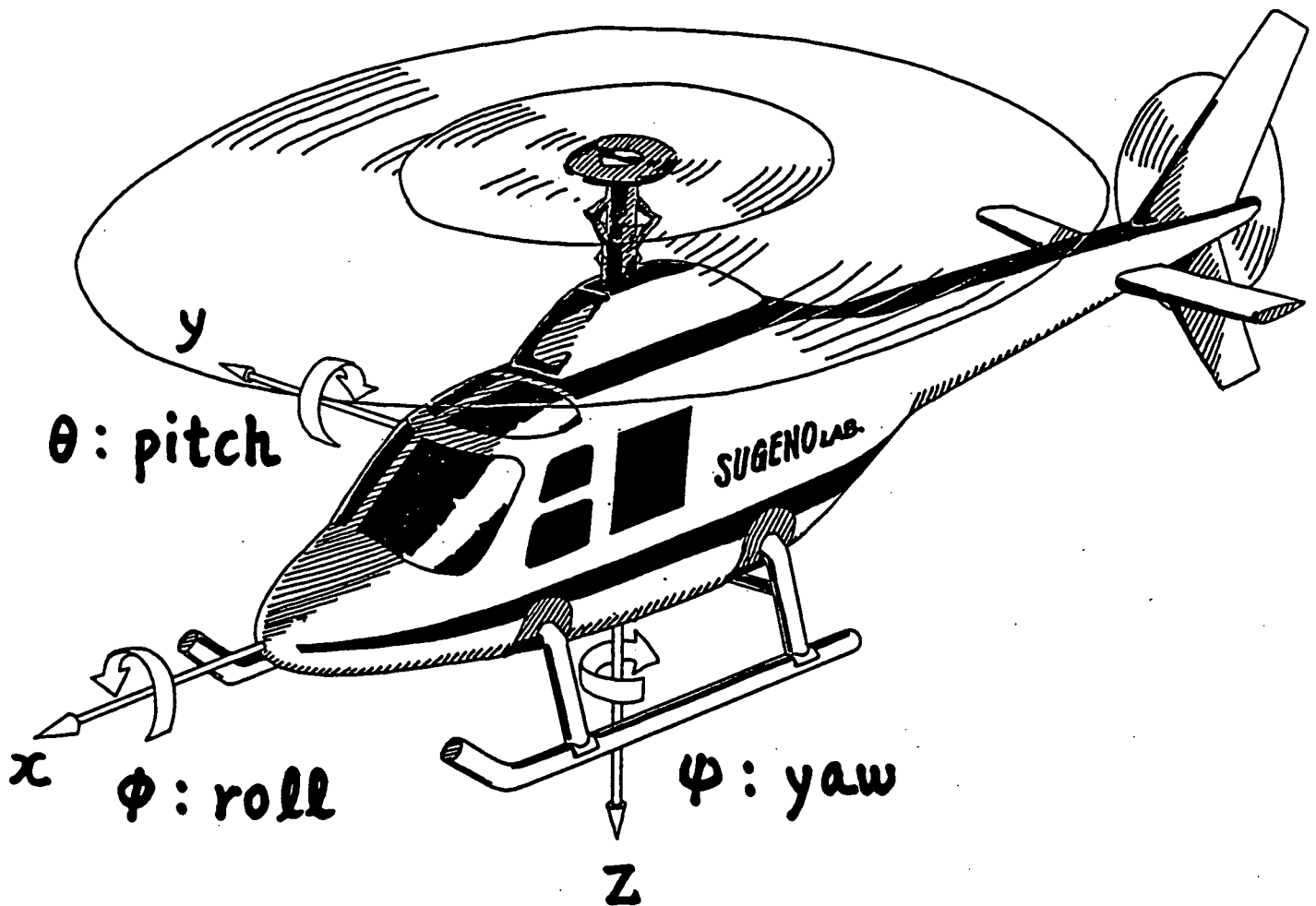
- o Automatic Autorotation Entry  
in Engine Failure  
(1989 - 1993)

Kawasaki Heavy Industry / TIT  
supported by STA

- o Unmanned Helicopter for Sea Rescue  
(1990 - 1991)

TOKIMEC / TIT  
supported by Ministry of  
Transportation

# Motion of Helicopter



measured variables :  $\ddot{x}$ ,  $\ddot{y}$ ,  $\ddot{z}$   
 $\dot{\phi}$ ,  $\dot{\theta}$ ,  $\dot{\psi}$

# Control of Movements

## Move

## Control

up/down



lift of main rotor  
(collective pitch level)

forward/backward

pitching



main rotor revolution  
(longitudinal stick)

left/right

rolling



main rotor revolution  
surface  
(lateral stick)

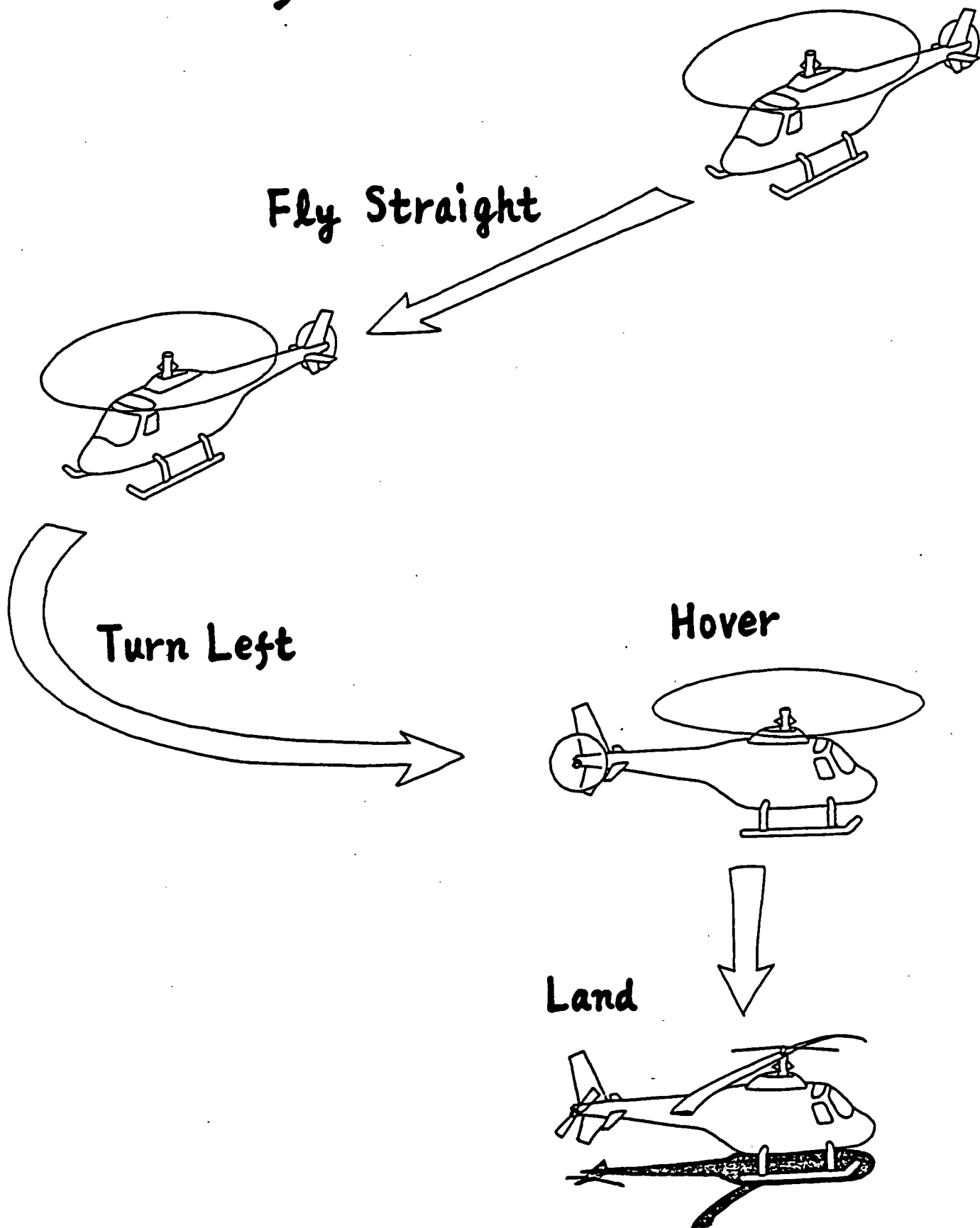
nose direction  
(left/right)

yawing

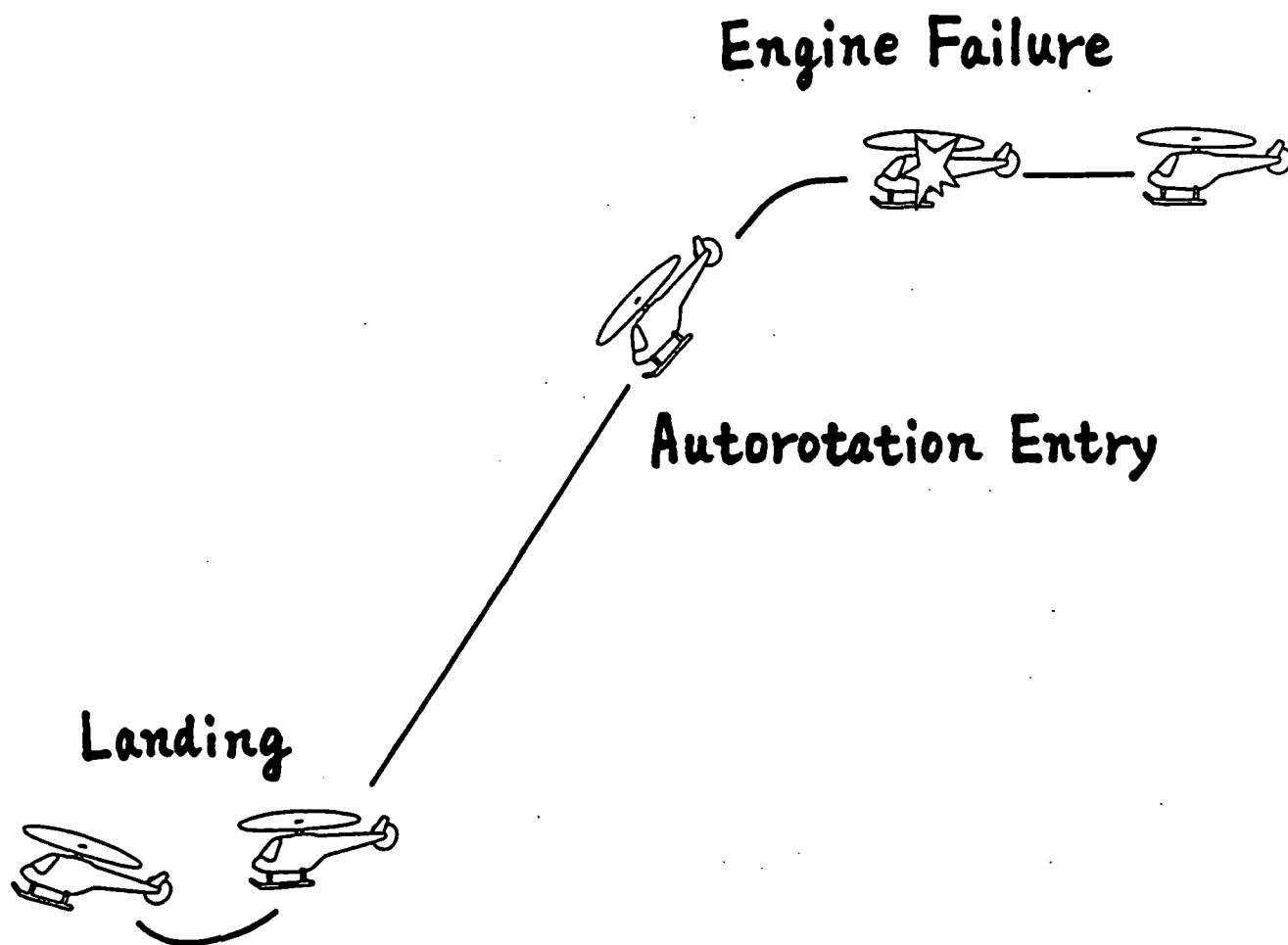


lift of tail rotor  
(directional pedal)

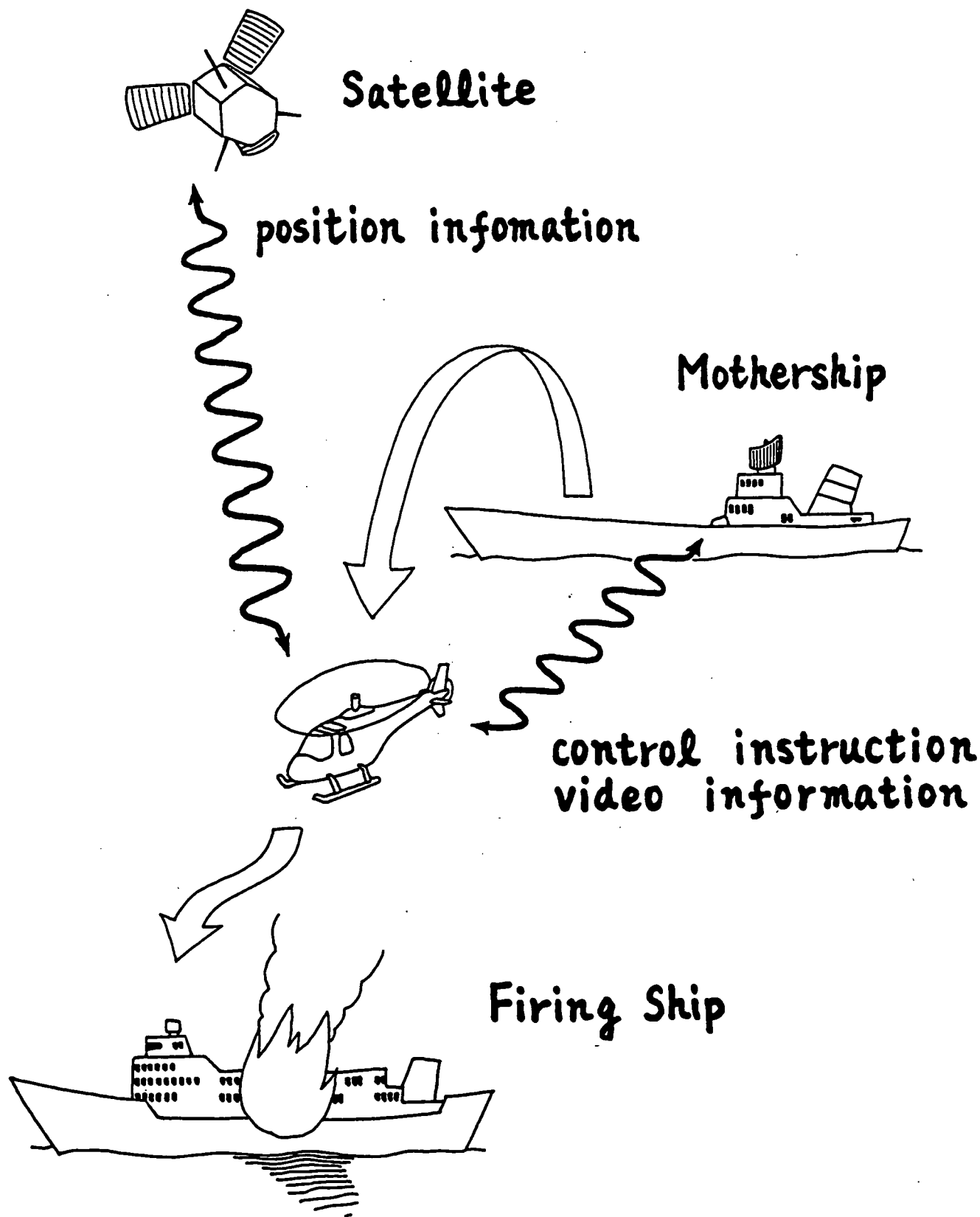
# Remote Control of Helicopter by Oral Instructions



# Automatic Autorotation Entry



# Unmanned Helicopter for Sea Rescue



# Linguistic Rules for Hovering

- 1) If the body rolls, then control the lateral in reverse
- 2) If the body pitches, then control the longi. in reverse
- 3) If the nose turns, then control the pedal in reverse
- 4) If the body moves sideways, then control the lateral in reverse
- 5) If the body moves back and forth, then control the longi. in reverse
- 6) If the body moves up and down, then control the collective in reverse



# Fuzzy Control Rules for Hovering (longi. stick control)

1) pitch is PO  $\rightarrow$  longi. is NE

2) " NE  $\rightarrow$  " PO

3)  $\frac{d}{dt}$  pitch is PO  $\rightarrow$  longi. is NE

4) " NE  $\rightarrow$  " PO

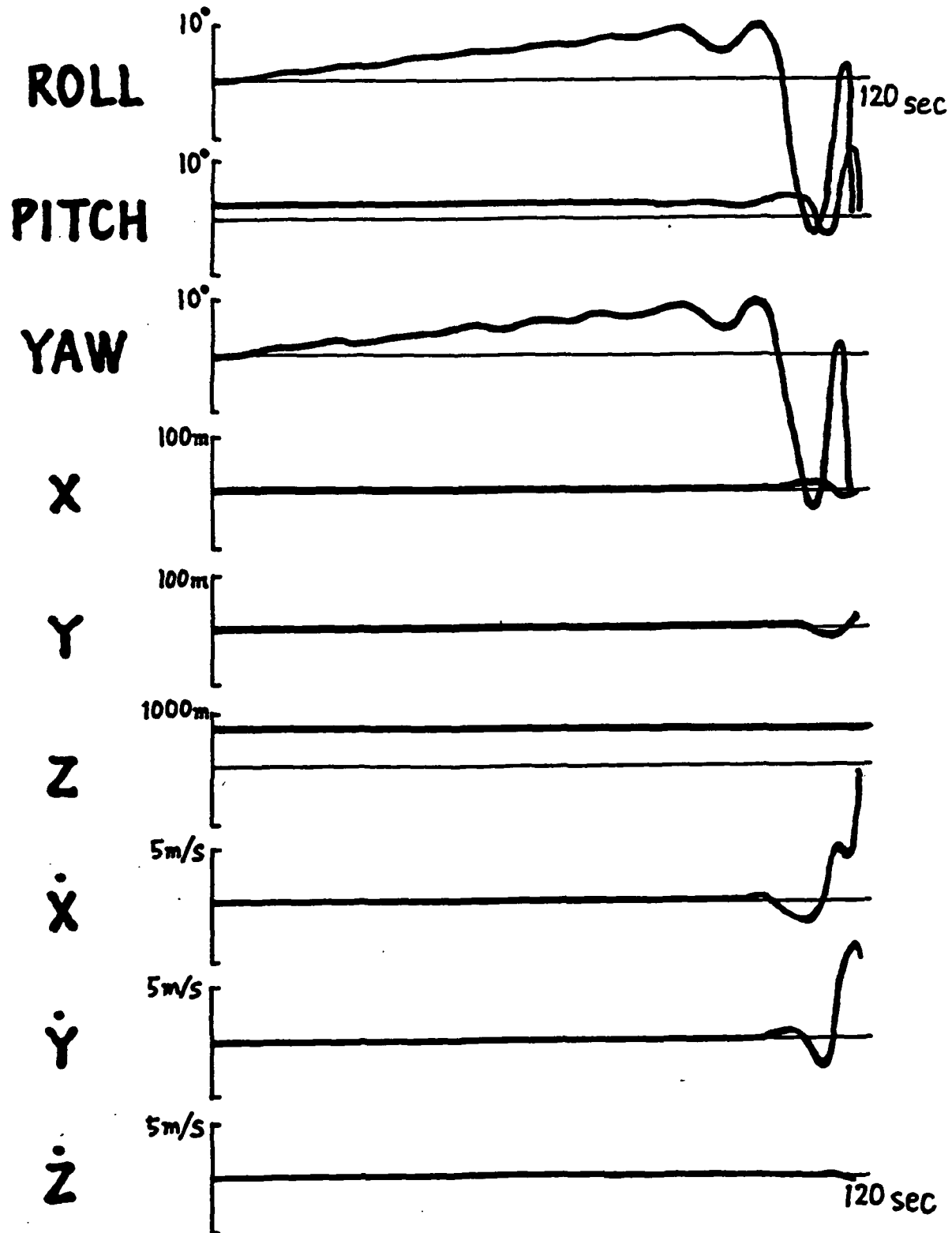
5)  $x$  is PO  $\rightarrow$  longi. is NE

6) " NE  $\rightarrow$  " PO

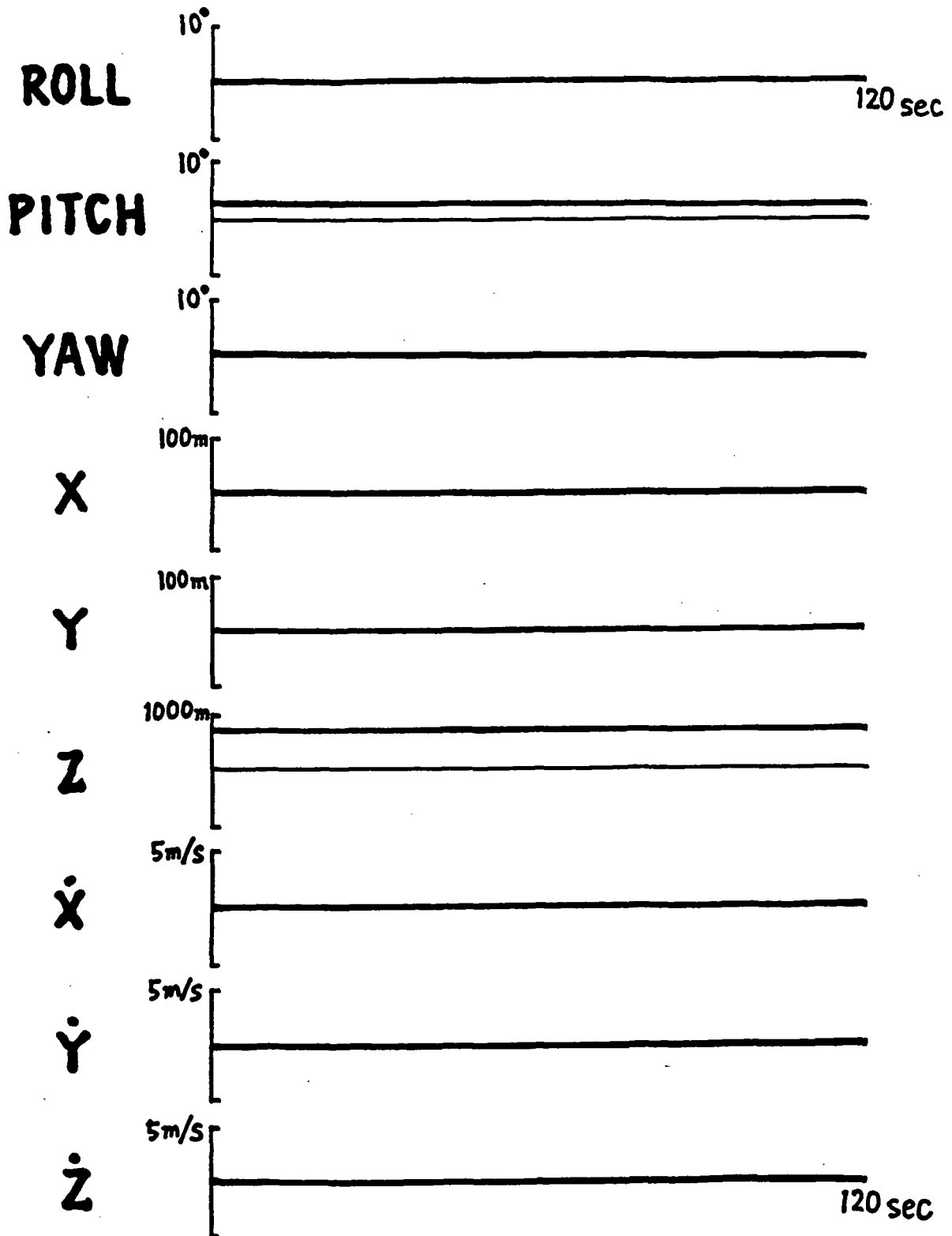
7)  $\frac{dx}{dt}$  is PO  $\rightarrow$  longi. is NE

8) " NE  $\rightarrow$  " PO

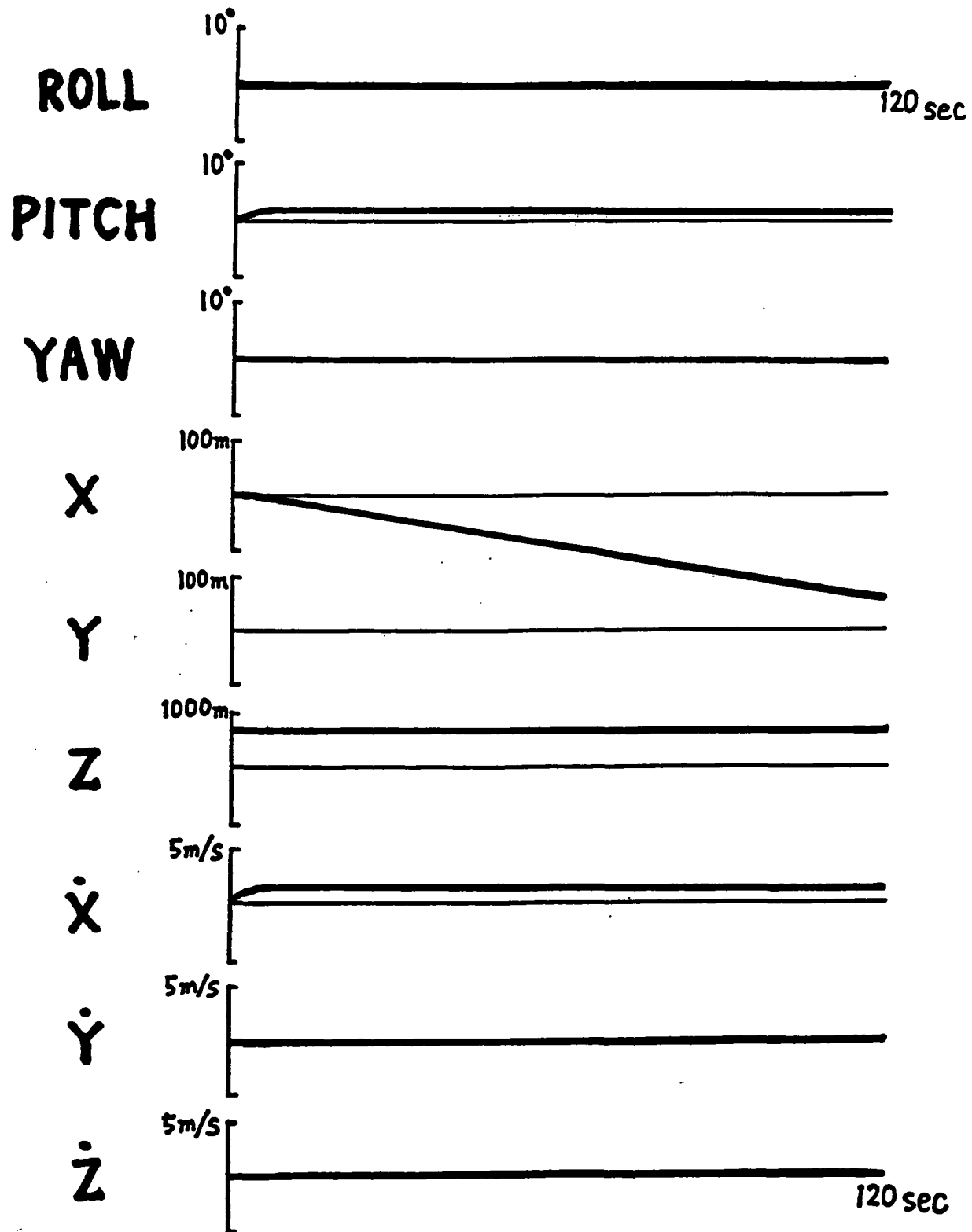
# Hovering without Control



# Hovering with Fuzzy Control



# Forward Flying Control in Low Speed



# Autorotation Entry by Fuzzy Control

(keep rotation speed of main rotor)

