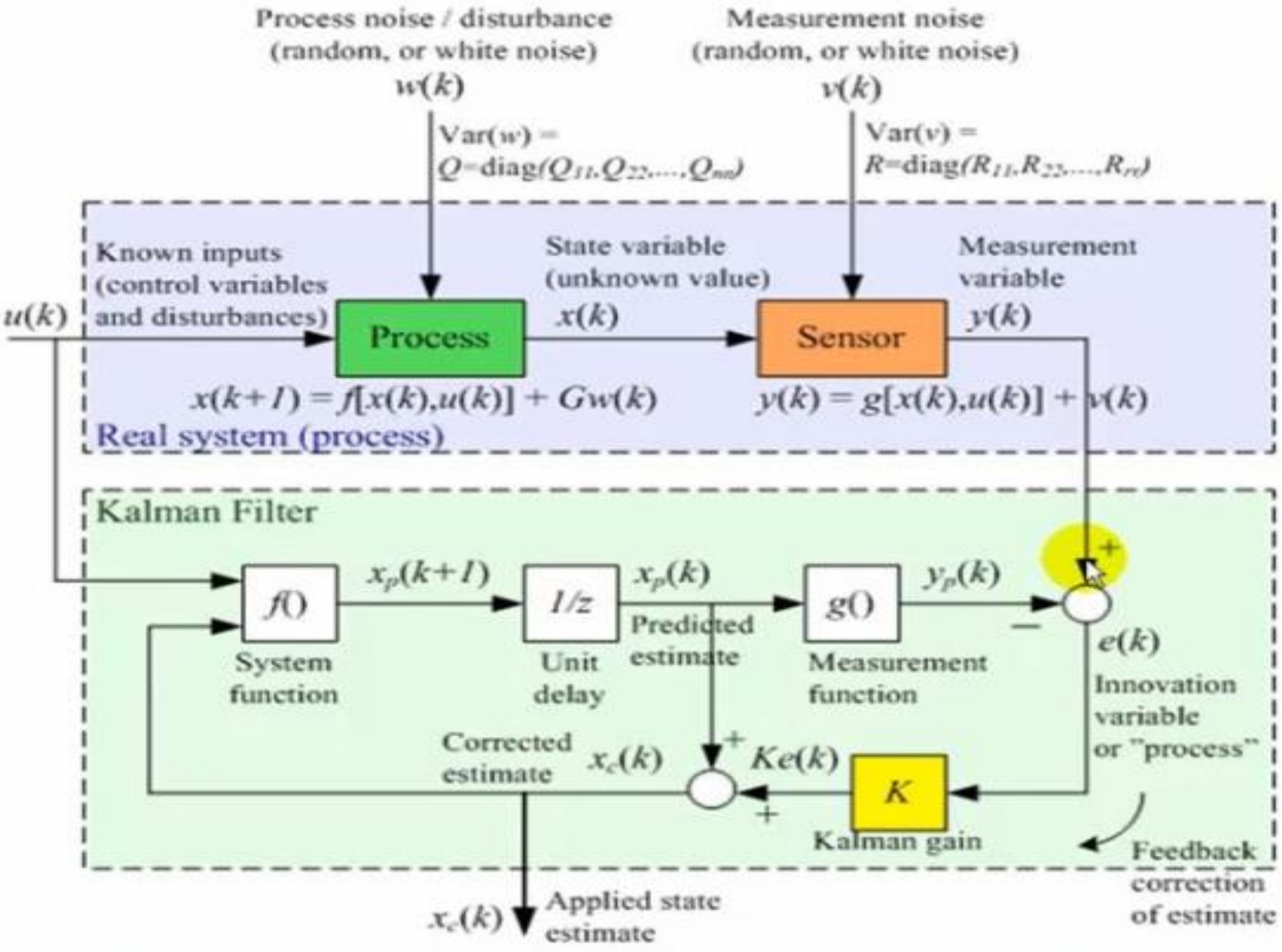
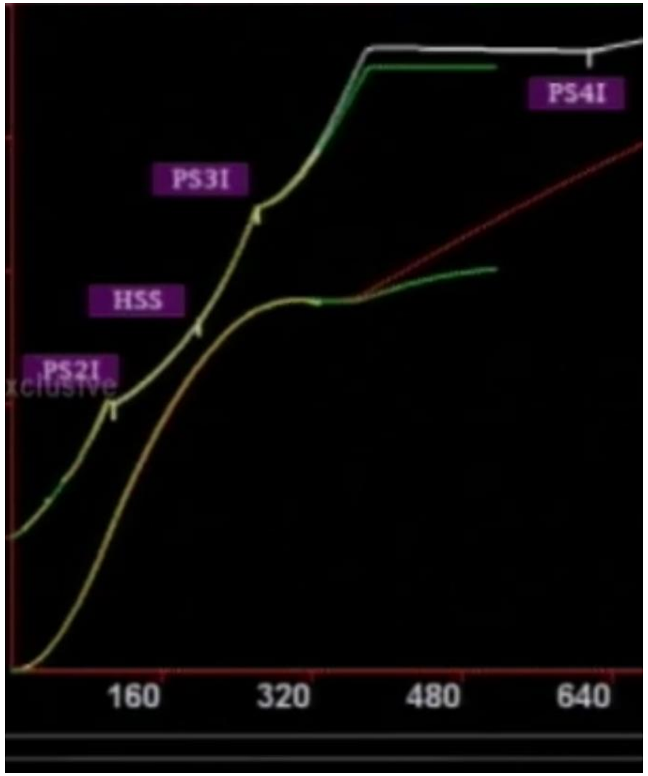
State space model -Robot

$$x_t = A_{t-1}x_{t-1} + B_{t-1}u_{t-1}$$

$$\begin{bmatrix} x_t \\ y_t \\ \gamma_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \\ \gamma_{t-1} \end{bmatrix} + \begin{bmatrix} \cos\gamma_{t-1} * dt & 0 \\ \sin\gamma_{t-1} * dt & 0 \\ 0 & dt \end{bmatrix} \begin{bmatrix} v_{t-1} \\ w_{t-1} \end{bmatrix} + \begin{bmatrix} noise_{t-1} \\ noise_{t-1} \\ noise_{t-1} \end{bmatrix}$$



Closed loop system

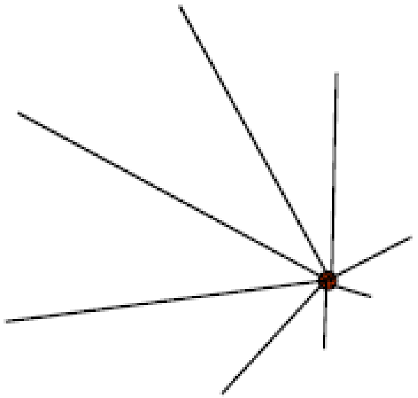


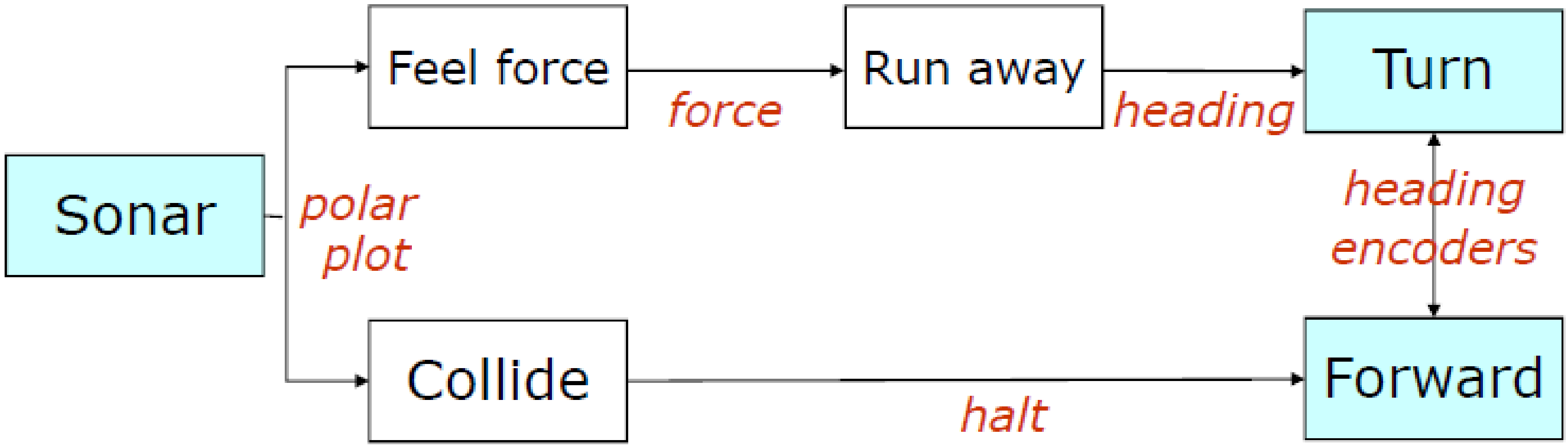
Actual vs predicted

Designing the architecture

Level 0: Avoid

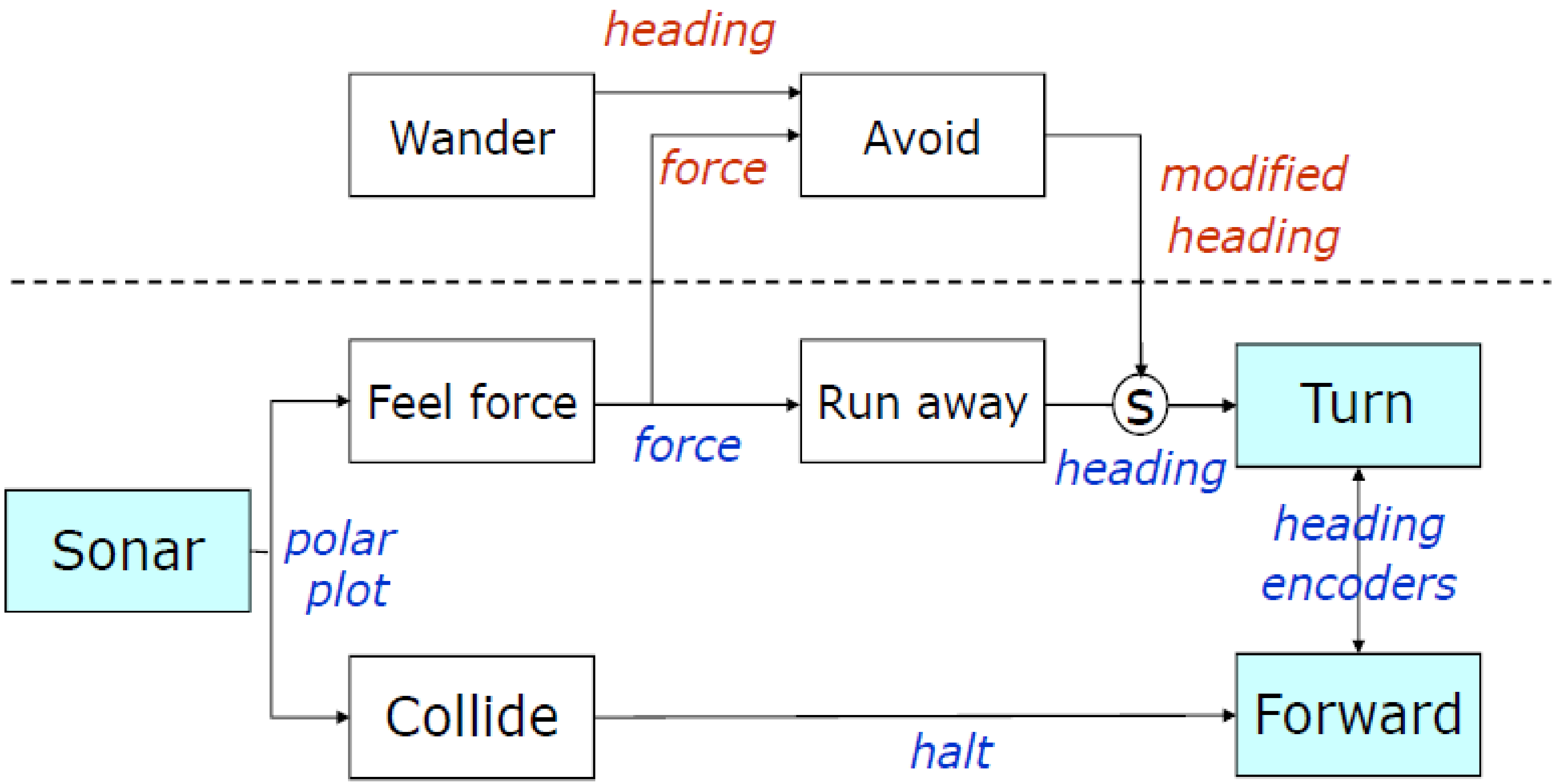
Polar plot of sonars



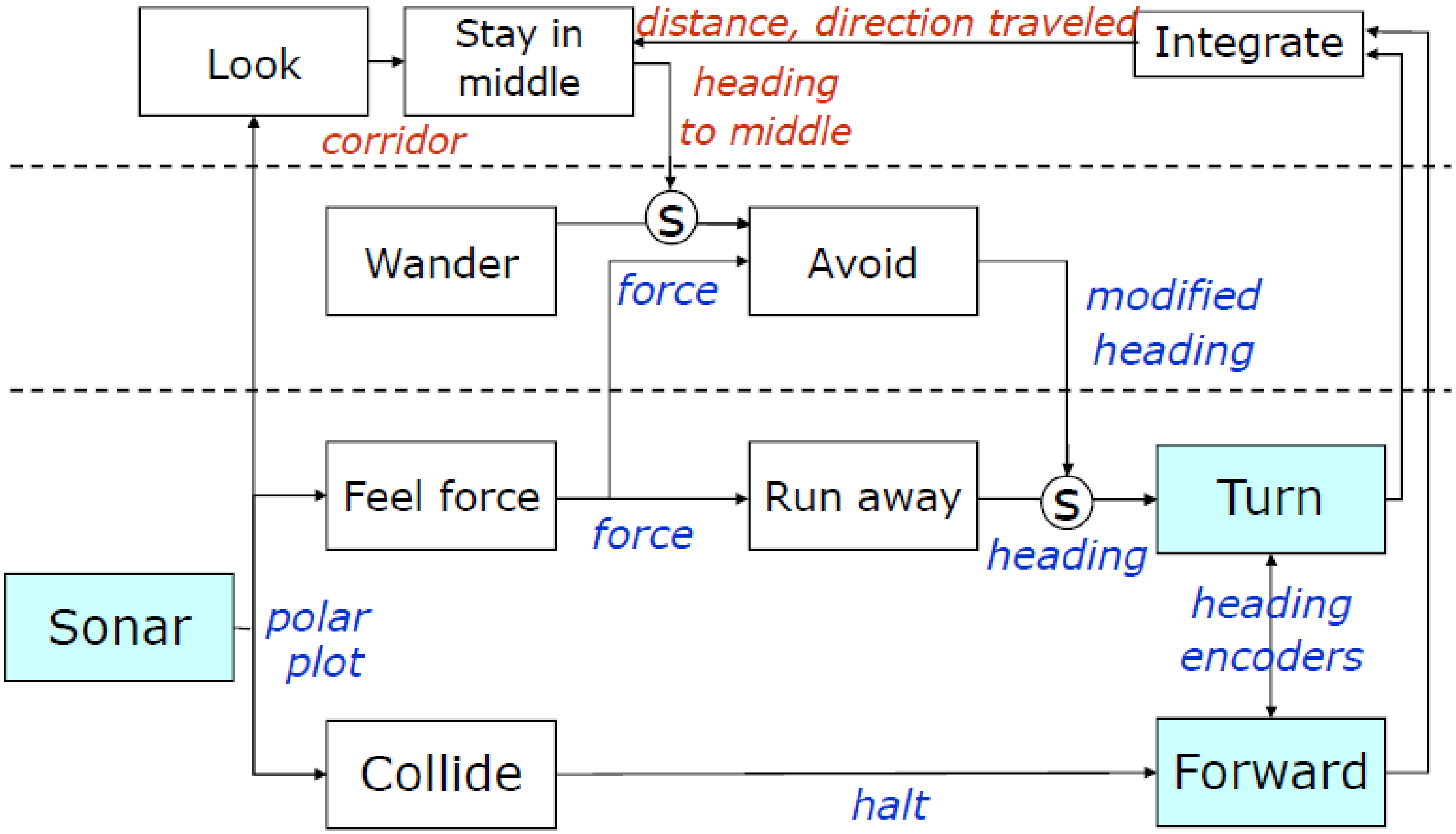


Simple mechanism on how robot will react

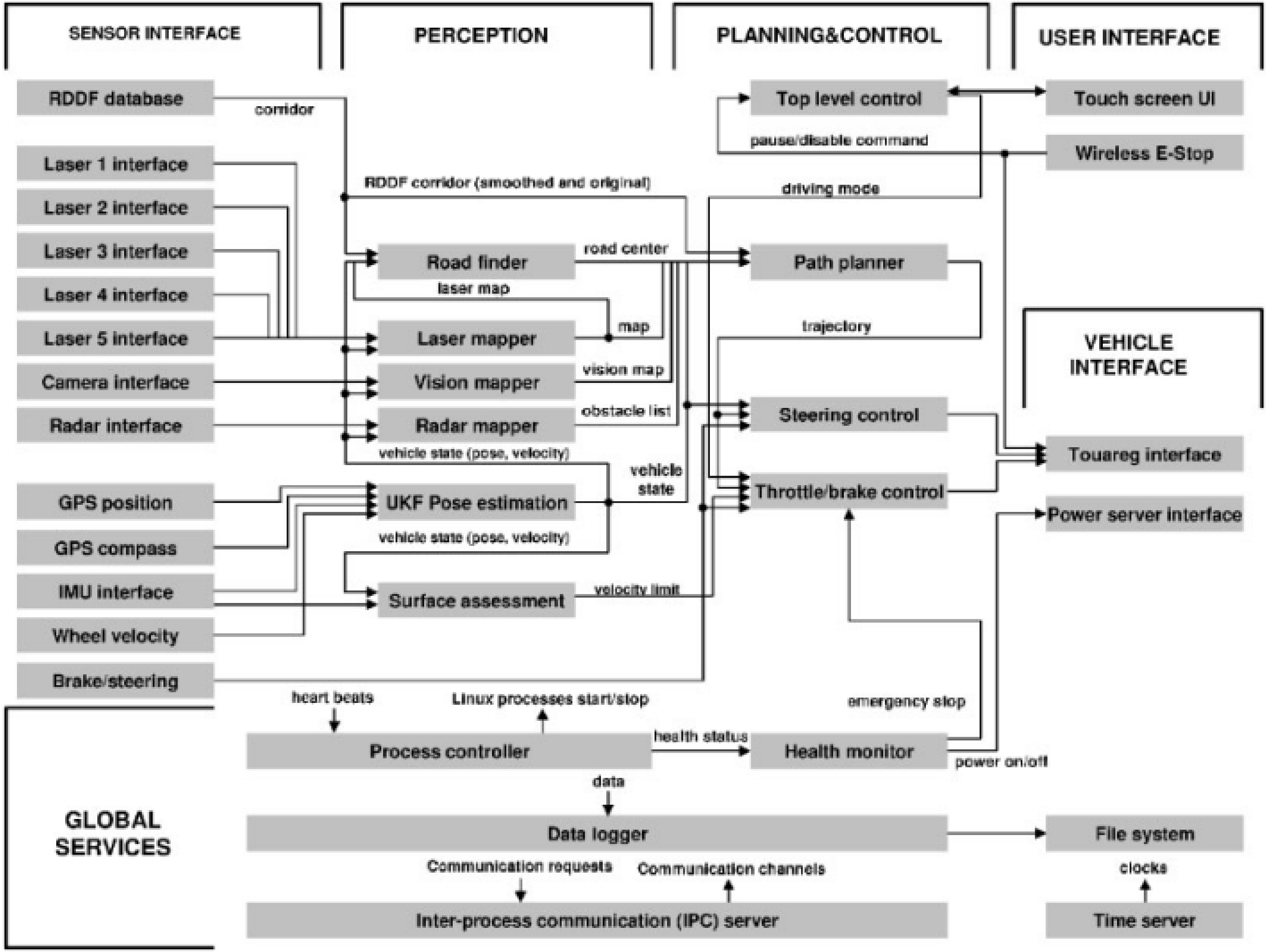
Level 1: Wander

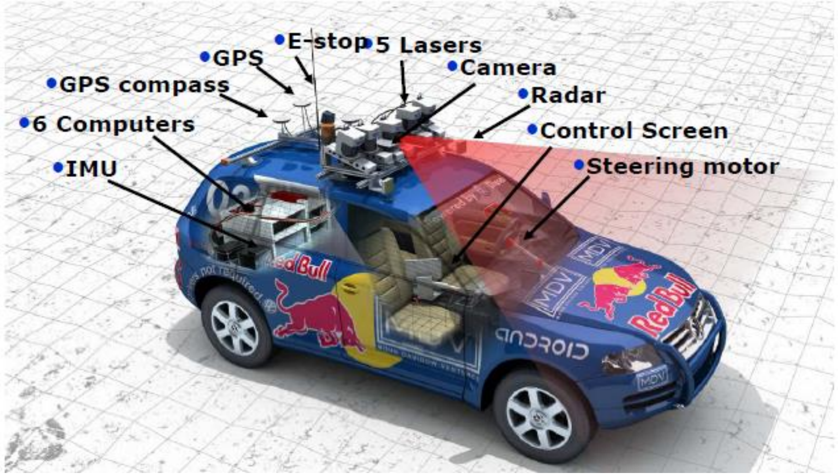


Level 2: Follow Corridor



Flowchart of Stanley software system





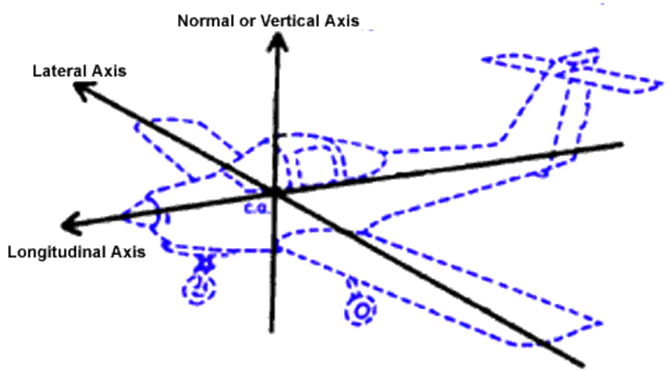
Fixed-Wing UAV

$$\text{Velocity vector, } \mathbf{v}= \begin{bmatrix} u \\ v \\ w \\ p \\ q \\ r \end{bmatrix} = \begin{bmatrix} \text{forward velocity} \\ \text{sideway velocity} \\ \text{vertical velocity} \\ \text{roll rate} \\ \text{pitch rate} \\ \text{yaw rate} \end{bmatrix}$$

$$\begin{bmatrix} X \\ Y \\ Z \\ L \\ M \\ N \end{bmatrix} = \begin{bmatrix} \text{forward force} \\ \text{sideway force} \\ \text{vertical force} \\ \text{rollmoment} \\ \text{pitchmoment} \\ \text{yawmoment} \end{bmatrix}$$

flat earth. non-rotation mass. aircraft is rigid body. aircraft is symmetric. constant wind. no rotating earth

6DOF



The Axes of an Airplane

- Longitudinal stability derivatives

Stability Derivative, X_u = -6.68
Angle of Attack Derivative, X_w = 4.1754
Elevator Deflection, $X_{\delta e}$ = -0.649
Thrust Deflection ,$X_{\delta T}$= 0
Compressibility Effect Derivative , M_u = -0.01376
Dimensional Pitching Moment , Derivative, M_w = 0.05852

Pitching moment (Elevator Deflection) ,$M_{\delta e}$ = -1.1526
Dimensionless Pitching Moment Derivative, M_q= -0.1179
Pitching moment (Thrust Deflection) ,$M_{\delta T}$= 0
Pitch Rate Derivative X_q = -1.16
Stability Derivative, Z_u = -0.6276
Angle of Attack Derivative, Z_w =-3.0503
Elevator Deflection ,$Z_{\delta e}$ = 26.0063
Thrust Deflection, $Z_{\delta T}$= 0
Pitch Rate Derivative, Z_q= 9.67

Lateral stability derivatives

Roll Rate ,Y_p = -0.05579
Aileron Deflection Derivative ,$Y_{\delta a}$ = 0
Yaw Rate Derivative, Y_r = 0
Sideslip Derivative Y_β = -4.5129
Rolling Moment , L_p = -0.3295
Rolling Moment L_r ,= 0.0205
Rolling Moment,$L_{\delta a}$ = 3.6299
Roll Acceleration ,L_β = 3.7096
Yawing Moment, $N_{\delta a}$ = 3.0316
Yawing Moment , N_p = 0.02025
Yawing Moment ,N_r = -0.10266
Yaw Acceleration ,N_β = 0.79937

$$\begin{bmatrix} \Delta u \\ \Delta w \\ \Delta q \\ \Delta \theta \end{bmatrix}' = \begin{bmatrix} X_u & Xw & Xq + w_0 & -g\cos\theta_0 \\ Z_u & Zw & Zq + w_0 & -g\sin\theta_0 \\ M_u & Mw & Mq & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta u \\ \Delta w \\ \Delta q \\ \Delta \theta \end{bmatrix} + \begin{bmatrix} X\delta e & X\delta T \\ Z\delta e & Z\delta T \\ M\delta e & M\delta T \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta \delta_e \\ \Delta \delta T \end{bmatrix}$$

$$\begin{bmatrix} \Delta \beta \\ \Delta p \\ \Delta \phi \\ \Delta r \end{bmatrix} = \begin{bmatrix} -0.2051 & -0.05579 & -21.9543 & 32.174 \\ -0.1686 & -0.3295 & 0.0205 & 0 \\ 0.03633 & 0.02025 & -0.10266 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta \beta \\ \Delta p \\ \Delta \phi \\ \Delta r \end{bmatrix} + \begin{bmatrix} 0 \\ 3.6299 \\ 3.0316 \\ 0 \end{bmatrix} [\Delta \delta a]$$

$$\begin{bmatrix} u \\ v \\ w \\ p \\ q \\ r \end{bmatrix} = \begin{bmatrix} \text{forward velocity} \\ \text{sideway velocity} \\ \text{vertical velocity} \\ \text{roll rate} \\ \text{pitch rate} \\ \text{yaw rate} \end{bmatrix}$$

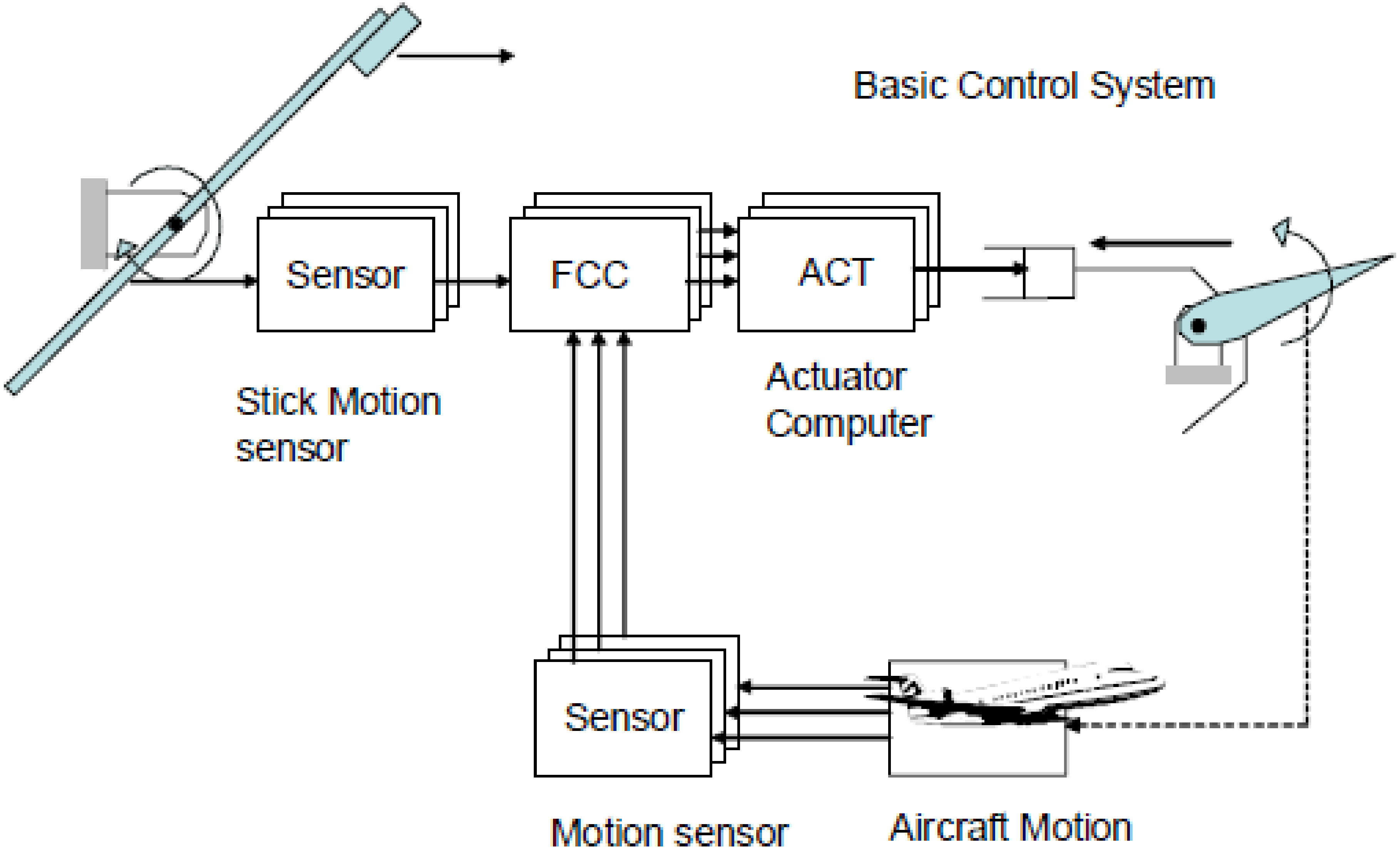
C_F \ ξ	Longitudinal				Lateral - Directional				
	u	α	q	δ_e	β	p	r	δ_a	δ_r
C_L	C_{Lu}	$C_{L\alpha}$	C_{Lq}	$C_{L\delta e}$					
C_D	C_{Du}	$C_{D\alpha}$	0	$C_{D\delta e}$					
C_M	C_{Mu}	$C_{M\alpha}$	C_{Mq}	$C_{M\delta e}$					
C_Y					$C_{Y\beta}$	C_{Yp}	C_{Yr}	$C_{Y\delta a}$	$C_{Y\delta r}$
C_l					$C_{l\beta}$	C_{lp}	C_{lr}	$C_{l\delta a}$	$C_{l\delta r}$
C_N					$C_{N\beta}$	C_{Np}	C_{Nr}	$C_{N\delta a}$	$C_{N\delta r}$

Control Derivative Coefficient

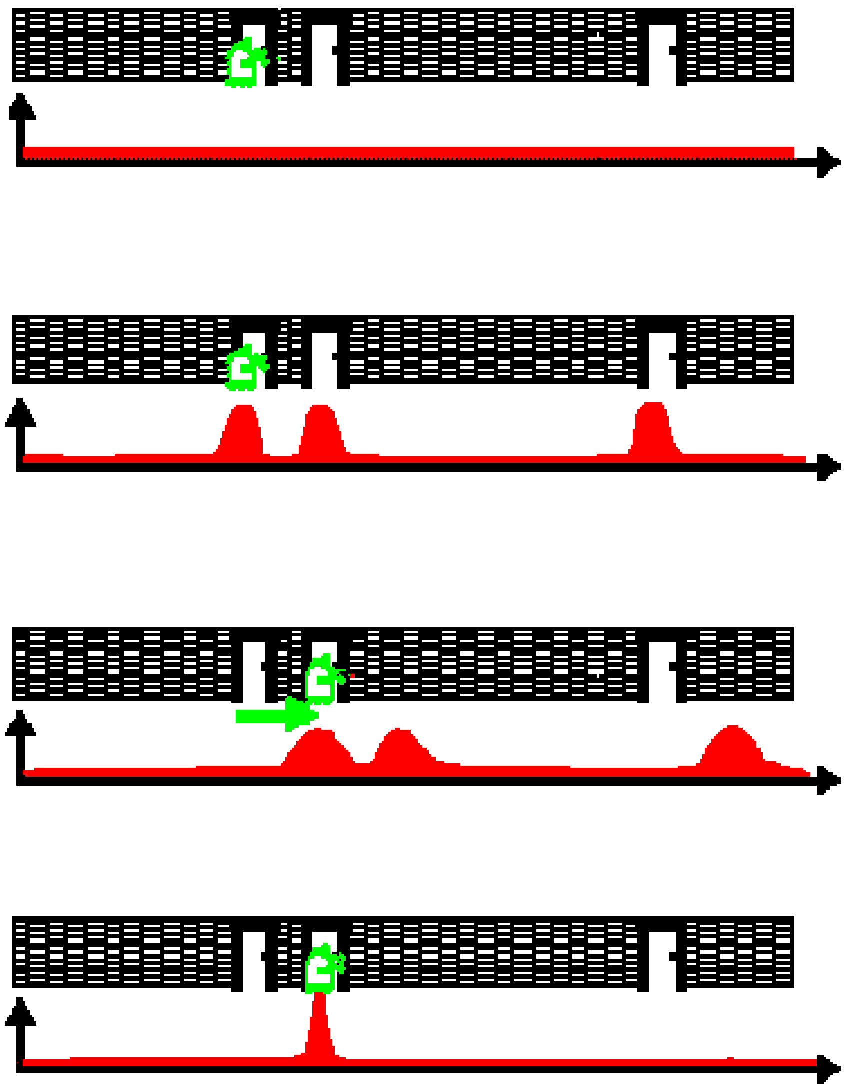
Static Stability Derivatives Coefficient For speed deviation

Dynamic Stability Derivative Coefficient

Static Stability Derivative Coefficient for angular deviation


Basic Control System
Sensor
FCC
ACT
Stick Motion sensor
Actuator Computer
Sensor
Motion sensor
Aircraft Motion

Probabilistic Robotics



Bayes Formula

$$P(x,y) = P(x \mid y)P(y) = P(y \mid x)P(x)$$

$$\Rightarrow$$

$$\boxed{P(x \mid y) = \frac{P(y \mid x)\ P(x)}{P(y)} = \frac{\text{likelihood} \cdot \text{prior}}{\text{evidence}}}$$

Normalization

$$P(x \mid y) = \frac{P(y \mid x)\ P(x)}{P(y)} = \eta\ P(y \mid x)\, P(x)$$