
AI and Drone Control

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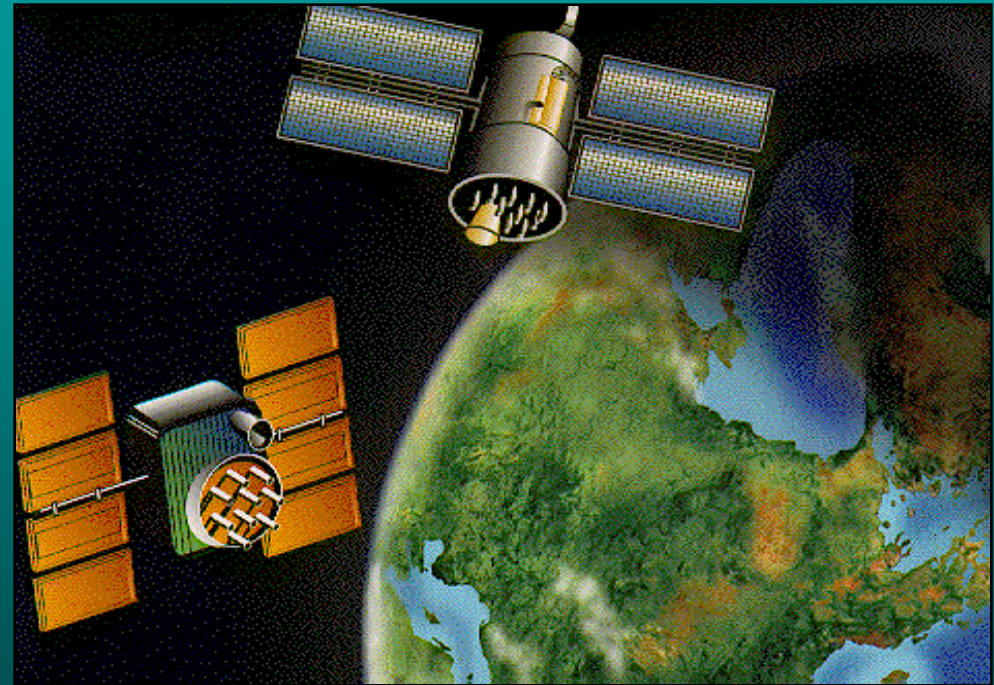




Foldable Drone

Background

Why Drone?



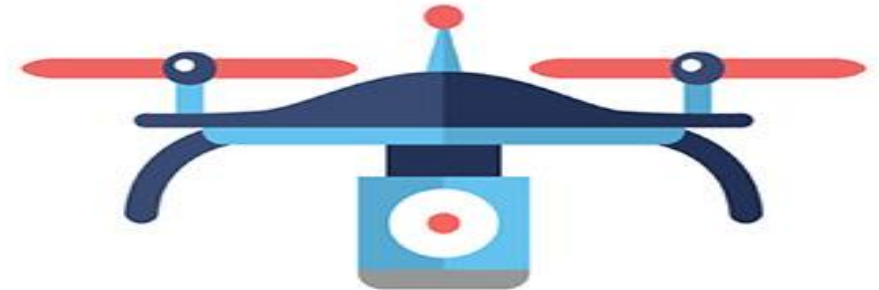
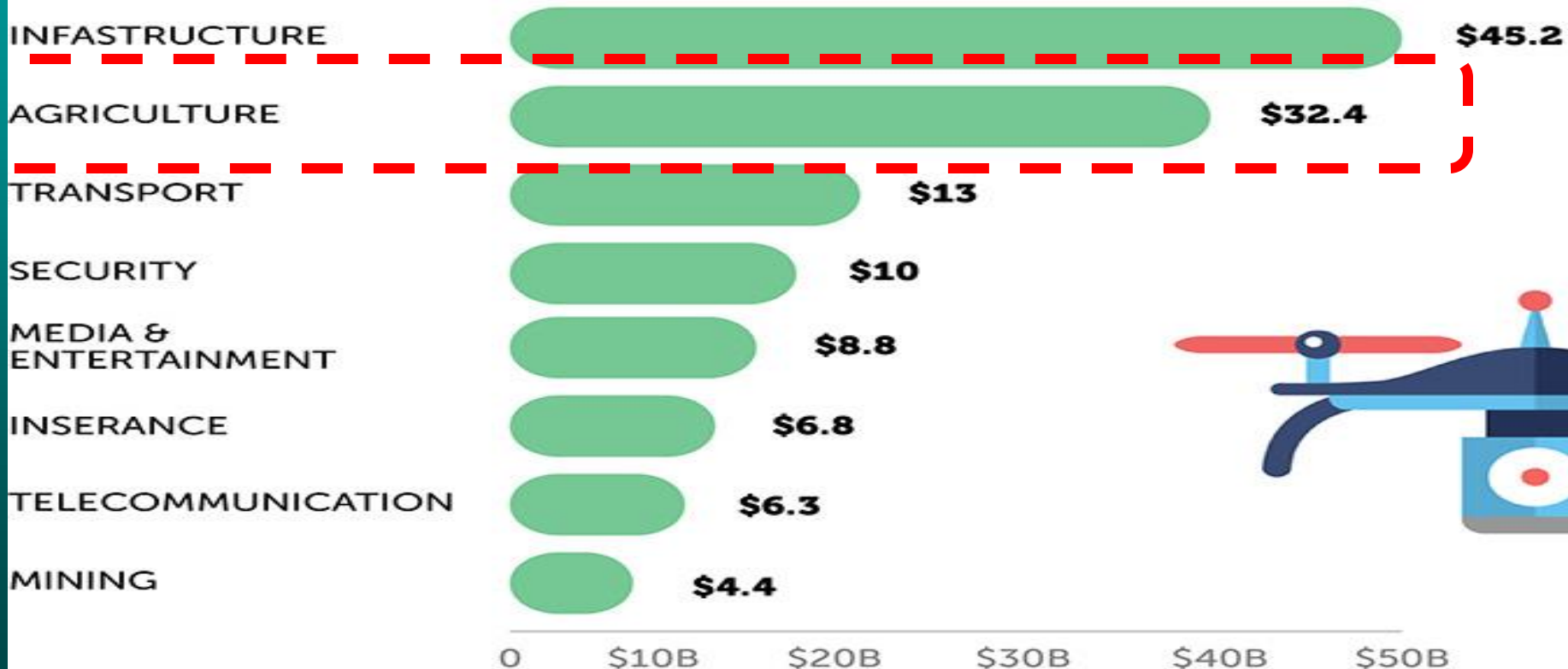
Drone Application Area

<https://www.videocaddy.com/blog/the-technical-and-market-might-of-aerial-videography/>

PREDICTED VALUE OF DRONES BY INDUSTRY

Value of business services and labor in billions

Referenced from businessinsider.com in "Commercial Unmanned Aerial Vehicle (UAV) Market Analysis - Industry trends, companies and what you should know" (Joshi, August 8, 2017)



Drone and Agriculture

Rice seeding Korea (농촌진흥청)



Rural Development
Administration



HENAN BEST MACHINERY CO.,LTD

BSM

- 0.1ha
- 1-person
- 15min
- Cost 1/6

- 0.1ha
- 2-3-person
- 1.5hr



African Drone



African Drone Forum: Feb 5-7, 2020



Drone Taxi

MLIT (Ministry of Land, Infrastructure and Transport), Korea

Bankkok Post (Thailand), Nov 25. 2020



- MLIT (Ministry of Land, Infrastructure and Transport) moves to launching unmanned air Taxi by 2025.
- South Korea is investing around 24.5 billion won (\$22 million) to develop the so-called K-Drone System.

Drone Taxi

Dubai ready

Digital Transformation

- Taxi-drone service ready to take off in Dubai
- Two technologies with an increasing number of applications are joining forces in Dubai to provide citizens with a service that was previously only in the imagination of filmgoers: autonomous flying cars or, in other words, taxi-drones.

Drone and Construction

Drones could save 100s of construction workers' lives each year?

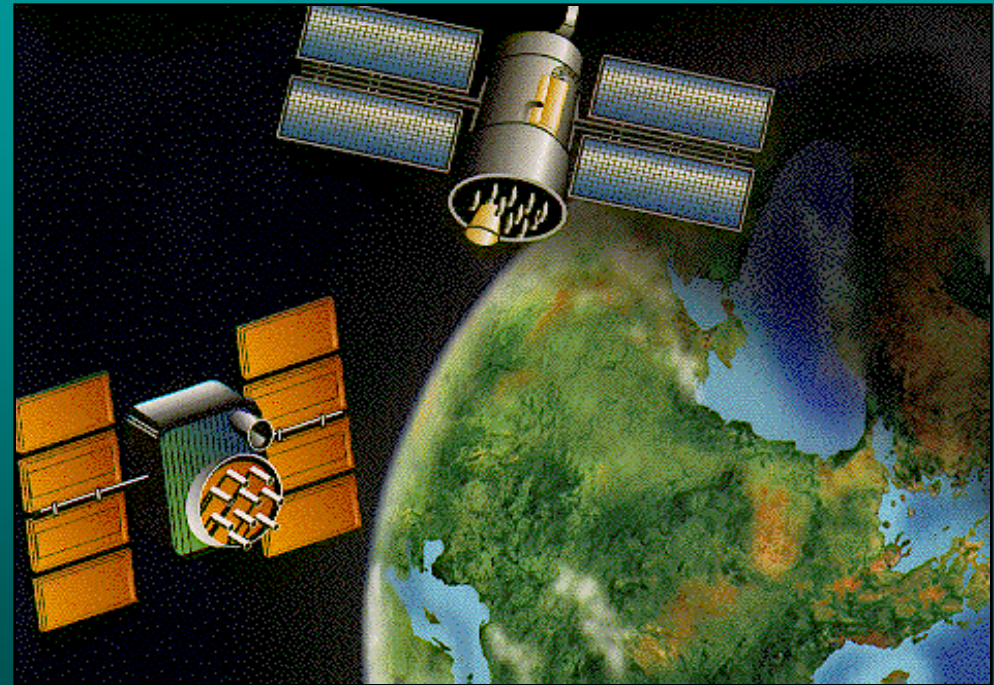


Drone Delivery



Section 1

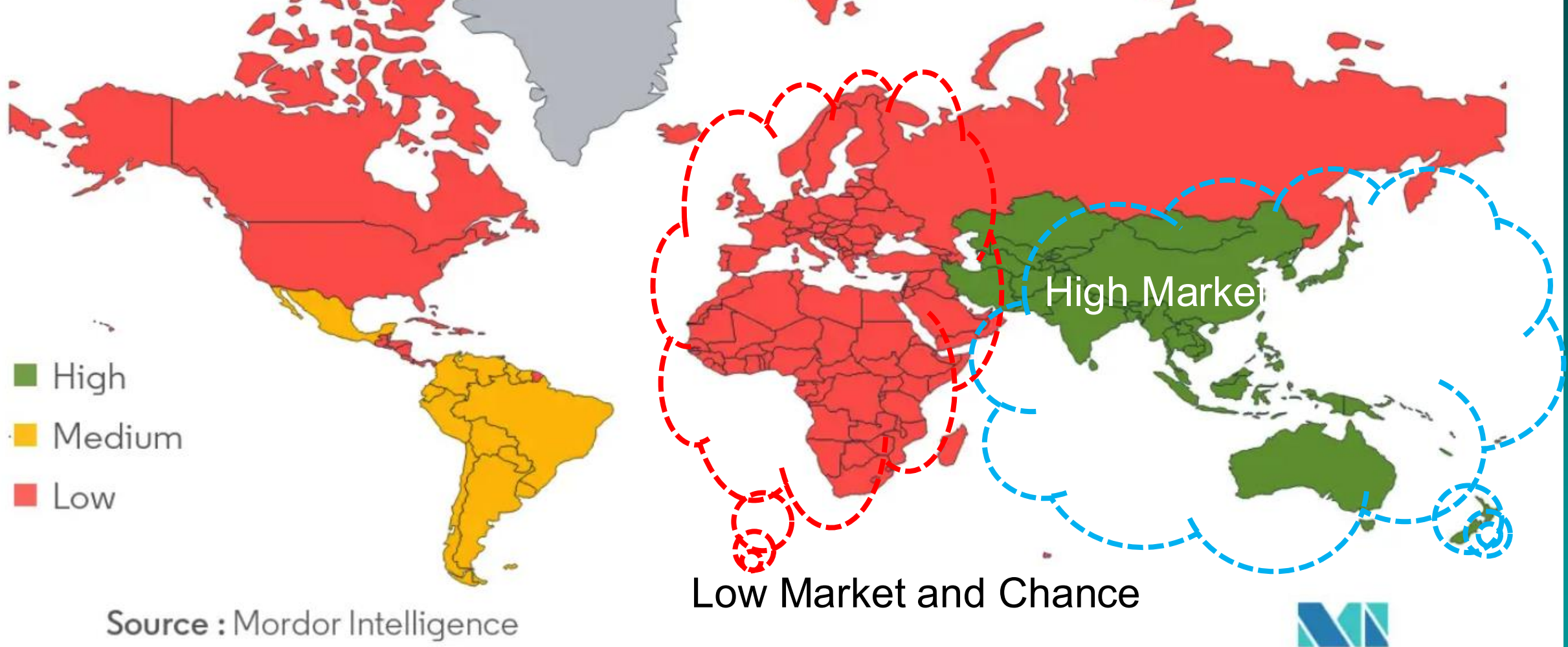
Drone Policy & Market



Drones Market - Growth Rate by Region (2020 - 2025)

Drone Market Growth (2020-2025)

<https://www.mordorintelligence.com/industry-reports/drones-market>



[To understand geography trends, Download Sample Report.](#)

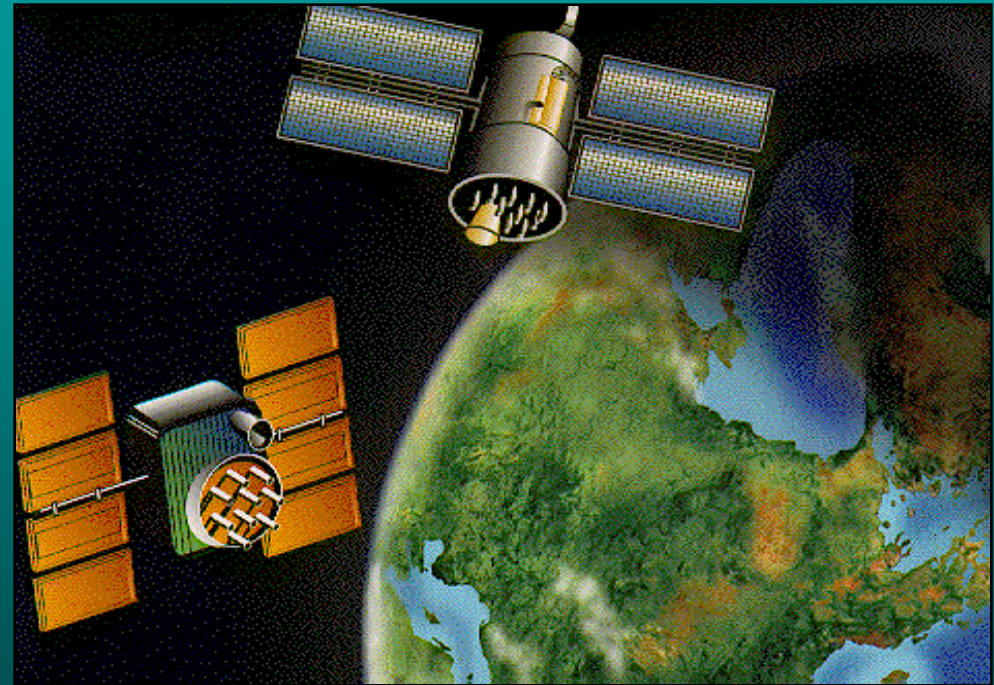
Major Drone Com.

Item	Com.	Products
Global	DJI	Agriculture/Phantom4 indoor racing
	Xiaomi	MI Drone
	ihang	ihang184
	Facebook	Internet Drone
	Intel	Typhoon
	Parrot	Drone, Plane drone
	Airbus	Survey for plane

Item	Com.	Products
Korea (200)	UMAC AIR (주)유 멕에어)	General / Racing
	Unicon system	Military/Industr
	KEVA(카바드론)	Military/Construction
	X Drone (엑스드 론)	Small multipurpose/Research
	Troizen (트로젠)	Racing/Toy
	Byrobot	Toy
	UVify (유비파이)	AI based Auto
	Huins (휴인스)	Embedded/Education
	JuniLab (주니랩)	Smartphone control
	EsV (이에스브이)	Race/Toy/Export
	Essen Digital (엣 센디지털)	Race/Expert

Section 3

What Kinds of Drone



What Types of Drone



What Types of Drone



Toy Drone



Technology Education Drone



Public Drone (Fire, Agriculture)



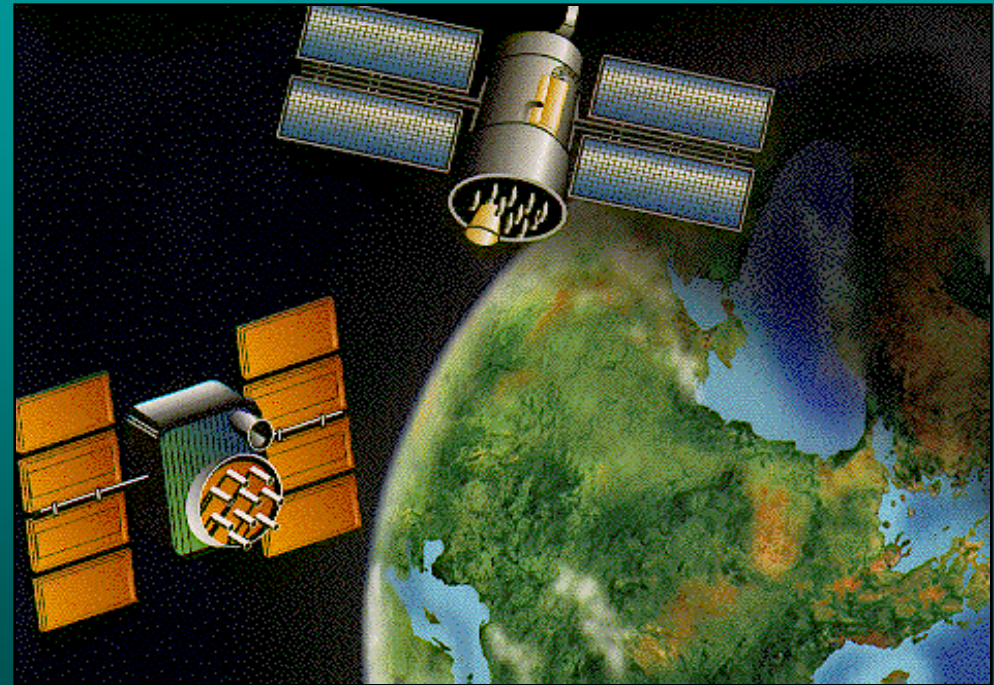
Commercial Drone



Racing Drone

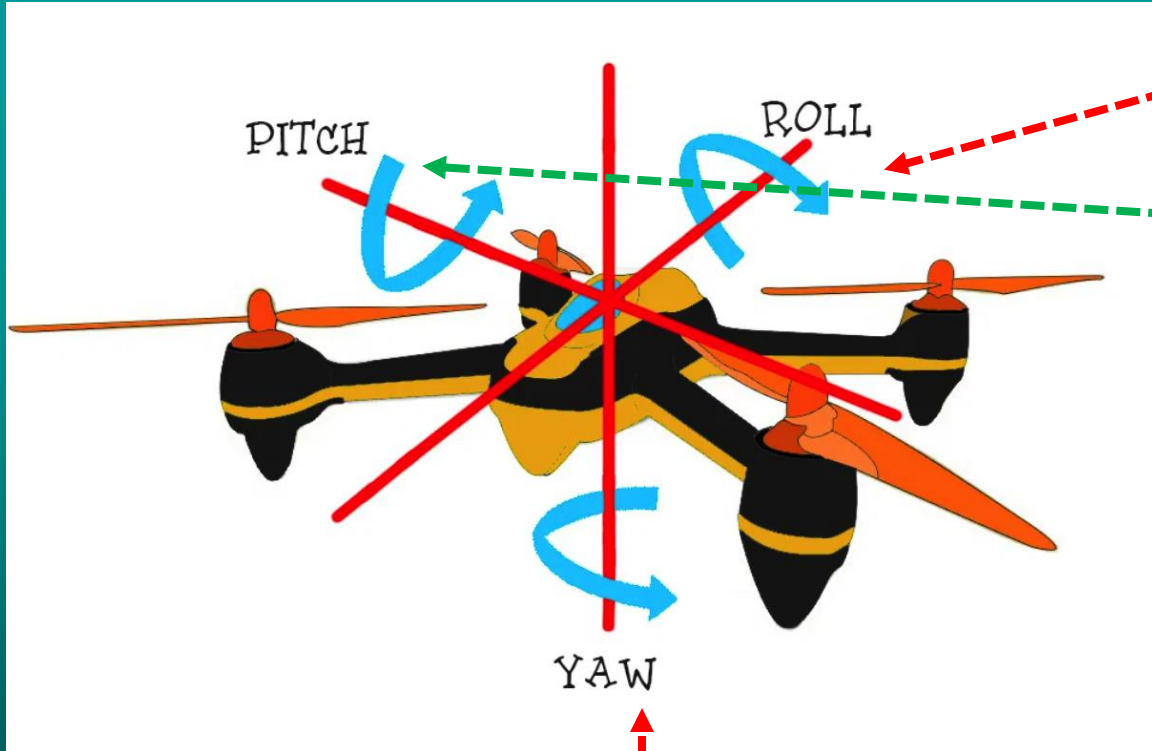
Section 4

Drone Control Technology



How to Move

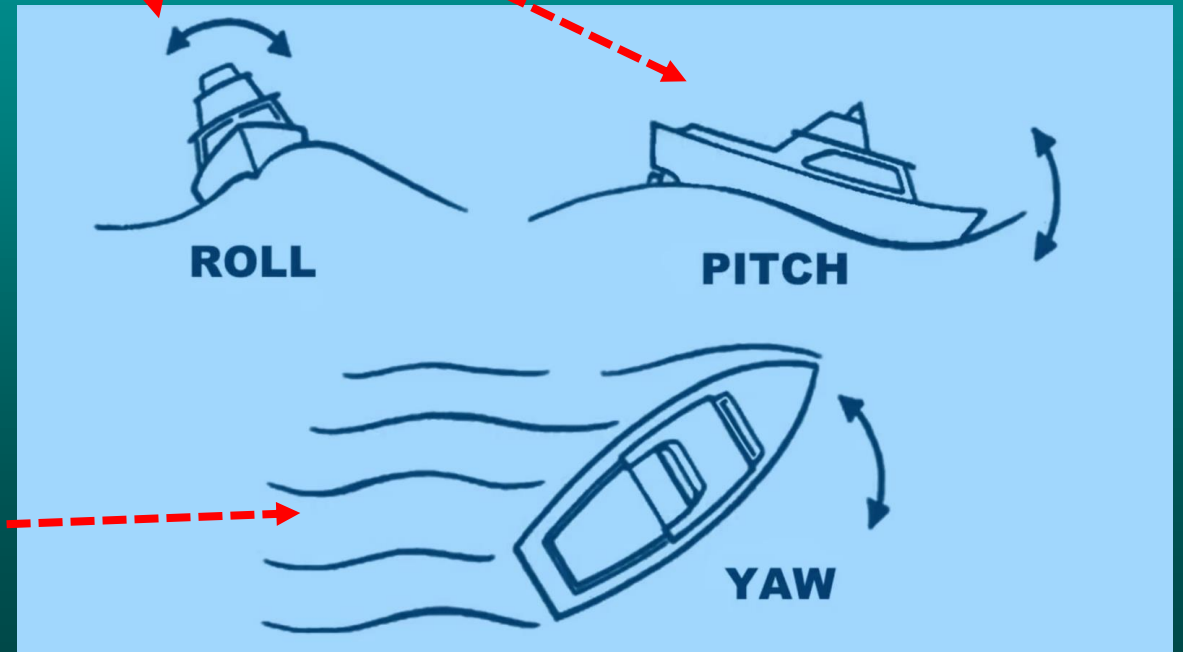
Pitch, Roll, Yaw

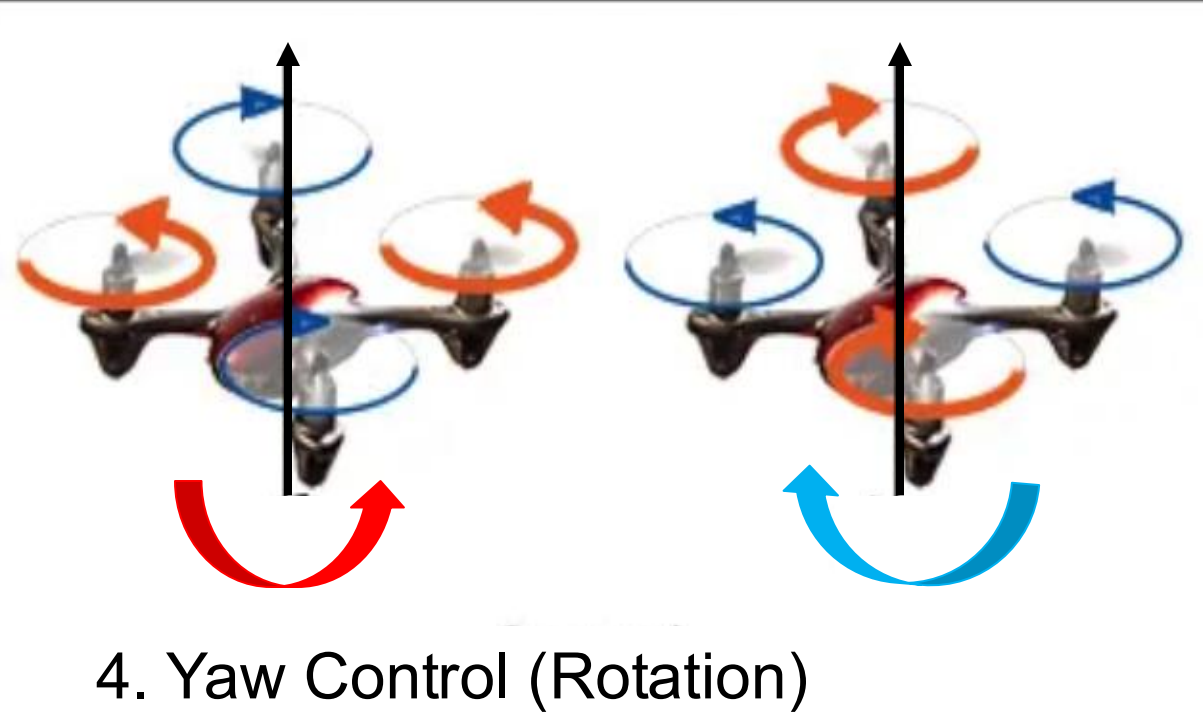
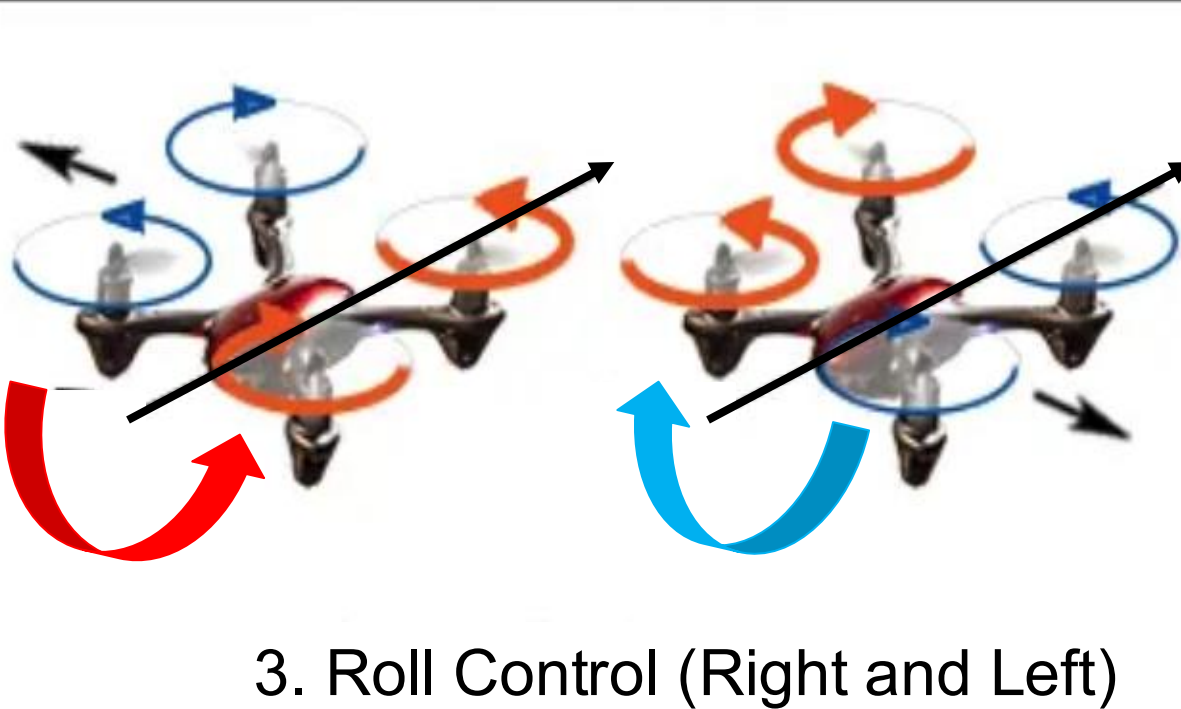
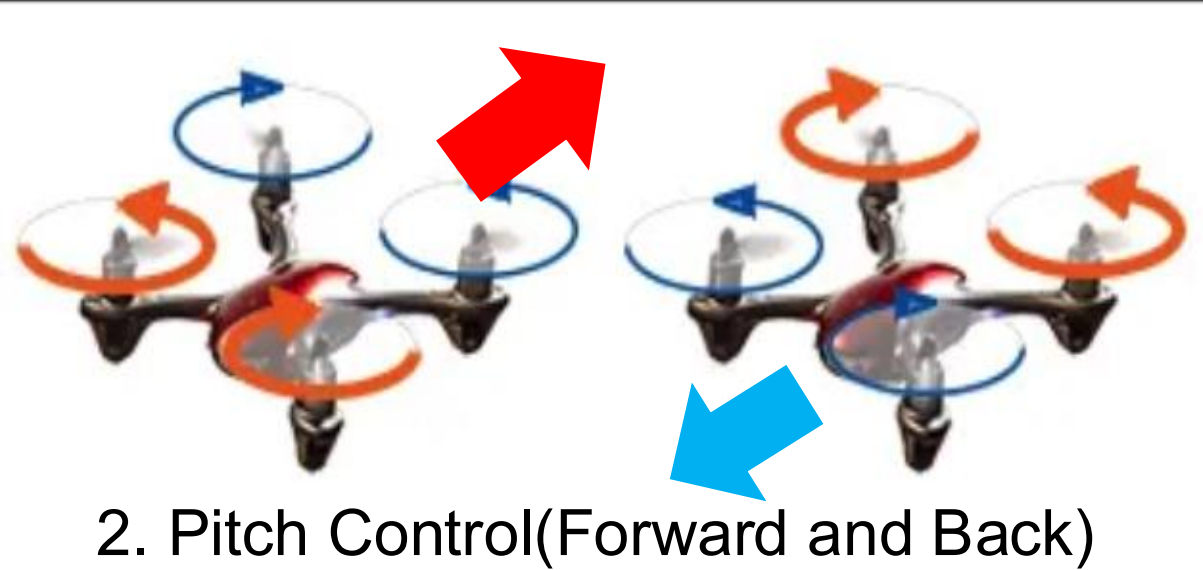


- Yaw: Rotation

- Roll: Moving to left or Right

- Pitch: Moving Forward or Backwards.





Dynamic Equation

R rotation matrix is as follows;

Moving Equation
(robot, Drone)

$$R = \begin{bmatrix} \cos \theta \cos \psi & \cos \theta \sin \psi & -\sin \theta \\ \sin \psi \sin \theta \cos \psi - \cos \phi \sin \psi & \cos \phi \cos \psi + \sin \phi \sin \theta \sin \psi & \sin \phi \cos \theta \\ \cos \phi \sin \theta \cos \psi + \sin \phi \sin \psi & \sin \theta \cos \phi \sin \psi - \sin \phi \cos \psi & \cos \theta \cos \phi \end{bmatrix}$$

T is a matrix for angular transformations[20].

$$T = \begin{bmatrix} 1 & \sin(\phi) \tan(\theta) & \cos(\phi) \tan(\theta) \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \frac{\sin(\phi)}{\cos(\theta)} & \frac{\cos(\phi)}{\cos(\theta)} \end{bmatrix}$$

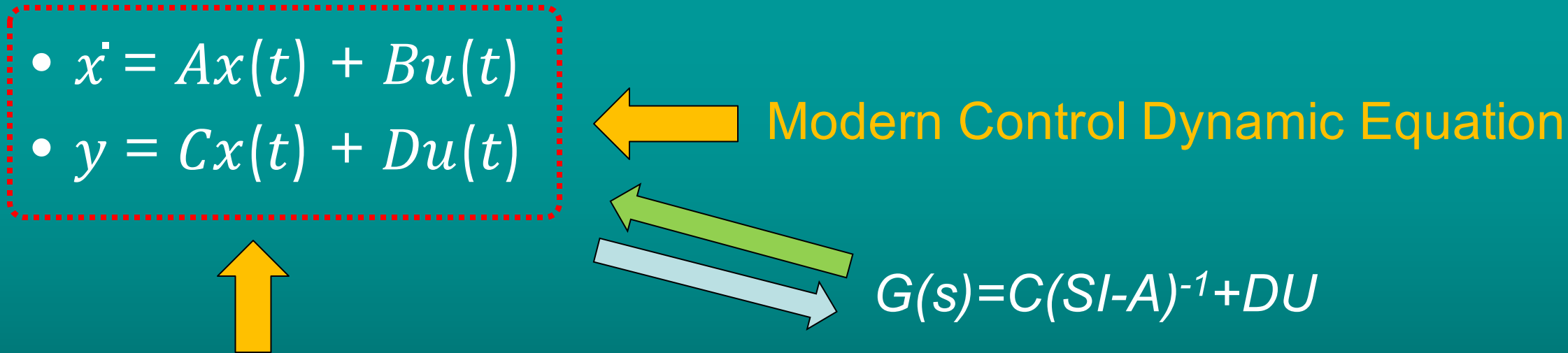
Transformation Matrix

$$\begin{aligned}
\dot{x} &= w[s(\phi) c(\psi) + c(\phi) c(\psi) s(\theta)] - v[c(\phi) s(\psi) - c(\psi) s(\phi) s(\theta) + u[c(\psi) c(\theta)]] \\
\dot{y} &= v[c(\phi) c(\psi) + s(\phi) s(\psi) s(\theta)] - w[c(\psi) s(\phi) - c(\phi) s(\psi) s(\theta) + u[c(\theta) s(\psi)]] \\
\dot{z} &= w[c(\phi) c(\theta)] - u[s(\theta)] + v[c(\theta) s(\phi)] \\
\dot{\phi} &= p + r[c(\phi) t(\theta)] + q[s(\phi) t(\theta)] \\
\dot{\theta} &= q[c(\phi)] - r[s(\phi)] \\
\dot{\psi} &= r \frac{s(\phi)}{c(\theta)} + q \frac{s(\theta)}{c(\phi)} \\
\dot{u} &= (vr - wq) + g s(\theta) \\
\dot{v} &= (wp - ur) - g c(\theta) s(\phi) \\
\dot{w} &= (uq - vp) - g c(\theta) s(\phi) \frac{U_1}{m} \\
\dot{p} &= \frac{I_y - I_z}{I_x} qr + \frac{U_2}{I_x} \\
\dot{q} &= \frac{I_z - I_x}{I_y} pr + \frac{U_3}{I_y} \\
\dot{r} &= \frac{I_x - I_y}{I_z} pq + \frac{U_4}{I_z}
\end{aligned}$$

12 variables

Dynamic Equation (5/9)

Dynamic Equation



The diagram illustrates the relationship between different representations of a dynamic system. At the top, a red dotted box contains the modern control dynamic equations: $\dot{x} = Ax(t) + Bu(t)$ and $y = Cx(t) + Du(t)$. A thick orange arrow points from these equations down to a list of steps. To the right, a green arrow points from the same equations to the transfer function $G(s) = C(sI - A)^{-1} + DU$, and a light blue arrow points from the transfer function back to the equations. The text 'Modern Control Dynamic Equation' is placed next to the green arrow.

- $\dot{x} = Ax(t) + Bu(t)$
- $y = Cx(t) + Du(t)$

Modern Control Dynamic Equation

$$G(s) = C(sI - A)^{-1} + DU$$

- After the linearization is done
- The input matrix is determined,

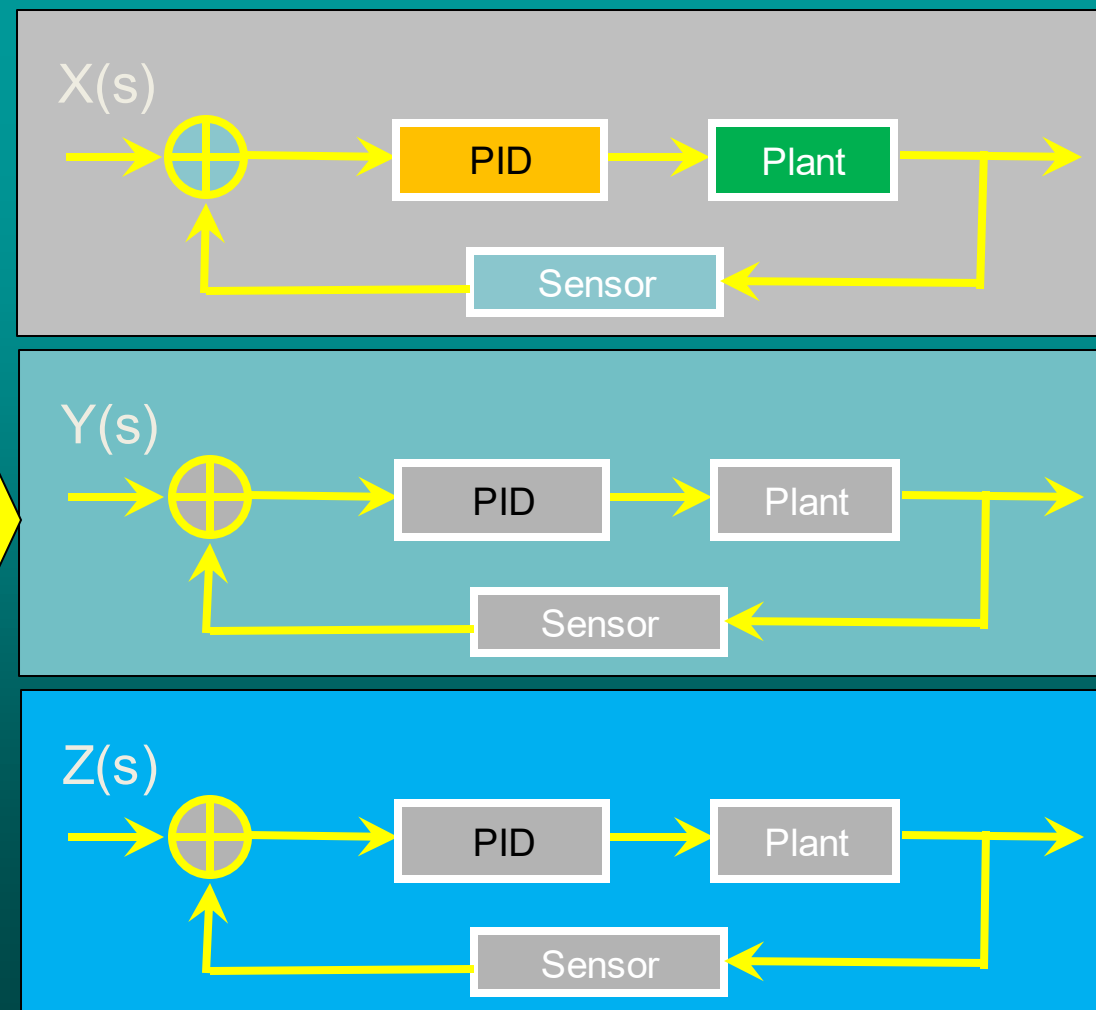
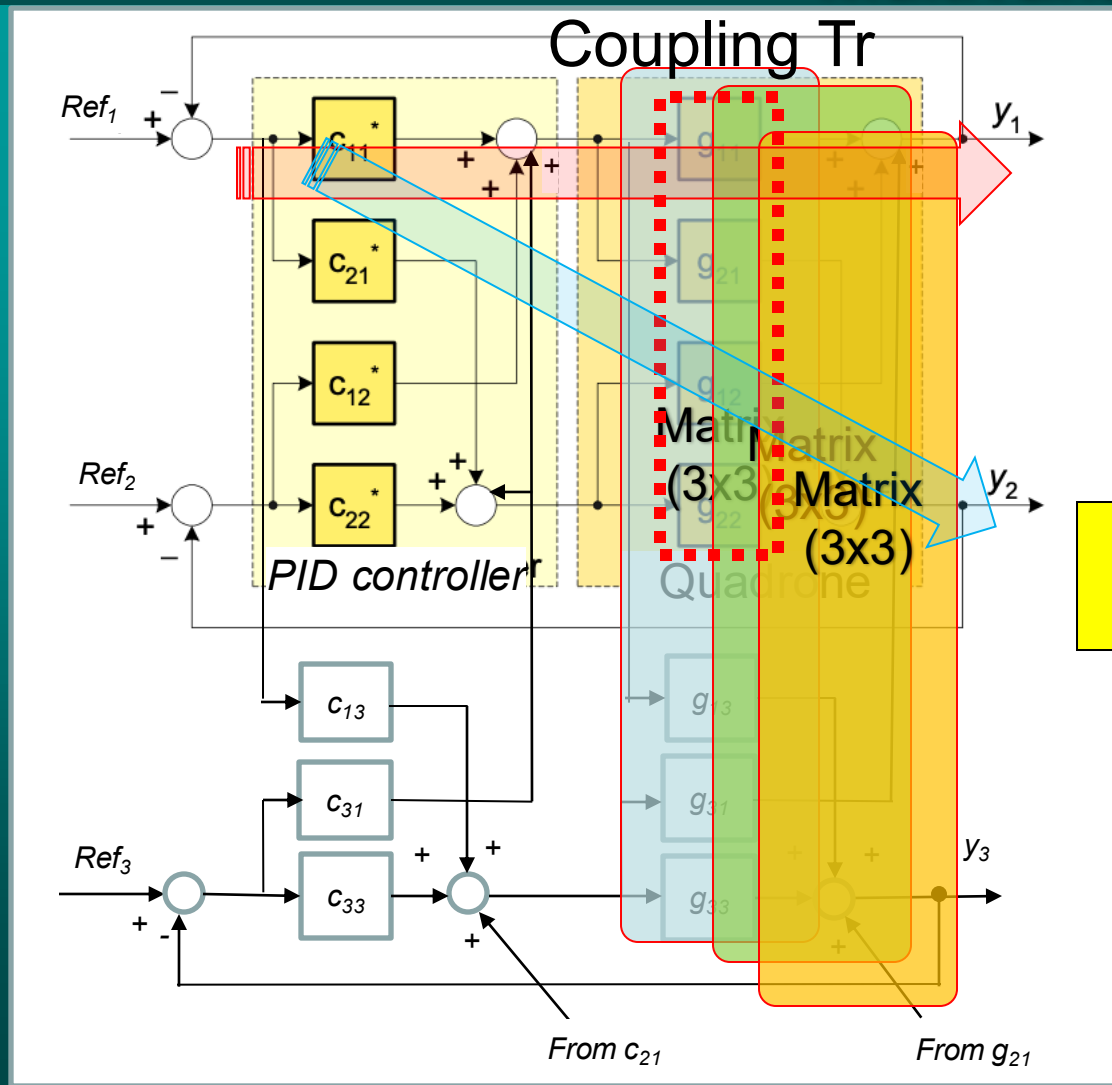
Dynamic Equation

- Accordingly quadrotor hover, longitudinal and lateral flight PID would be as follows, respectively:

$$\begin{aligned} \bullet u(t) &= K_{ph} e(t) + K_{ih} \int e(v) dv + K_{dh} de(t)/dt \\ \bullet u(t) &= K_{p\theta} e(t) + K_{i\theta} \int e(v) dv + K_{d\theta} de(t)/dt \\ \bullet u(t) &= K_{p\psi} e(t) + K_{i\psi} \int e(v) dv + K_{d\psi} d\psi/dt \end{aligned}$$

Drone Control

Multivariable Control





Multijoint Dancing Robot with Emotion Function

Conclusion

