Technology, Device and Application of UAV in Humanitarian Aid

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Overview

- UAVs come in a wide variety
- size, range, and capacity for autonomous flight.
- Controlled remotely by a human pilot on the ground, pre-set coordinates or patterns, or land if they lose contact with the pilot

Medium to large system UAVs:

- range from dozen of kilograms to the size of manned plane
- fly at high or medium altitudes for hours or days at time, hundreds or thousands of miles from their operators
- very expensive
- sophisticated base stations and pilot training

Predator (1,020 Kg)

MQ-9 Reaper (4,500 Kg)

Global Hawk (15, 000 Kg)

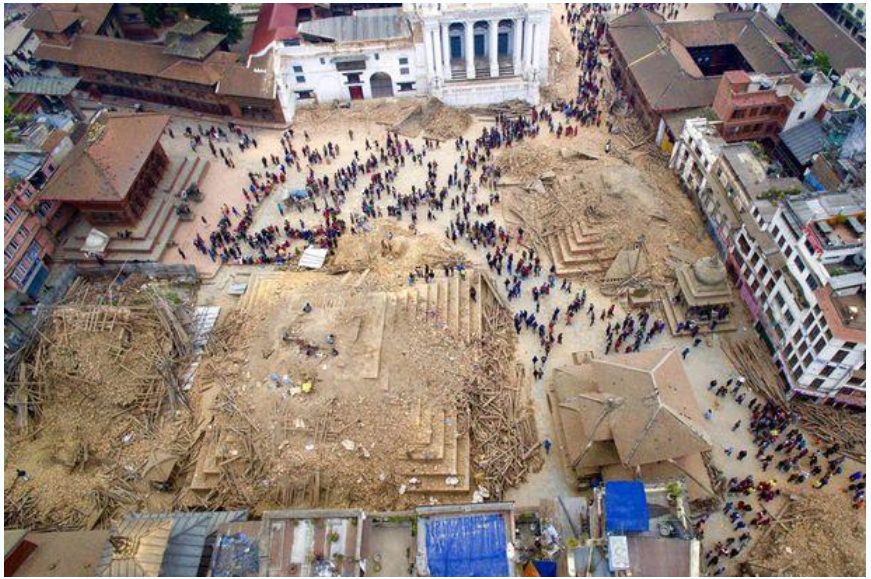
Small System (mini and micro-UAVs):

- small
- fix-wing aircraft and rotor aircraft
- flight range is limited
- flight time under an hour
- simple operating system
- can carry sophisticated cameras and GPS equipment
- cost can range from 5000 to several hundred thousand dollars

UAV Applications in Humanitarian Context

1. Nepal Earthquake 2015:

- 7.8 magnitude earthquake struck Nepal in April 2015. 5000 relief workers and rescuers scrambled to assist the 8.1 million affected people, more than a quarter of Nepal's population.
- **Expert from Ontario, used UAVs equipped with thermal imaging cameras to identify survivors.**
- **The drone mapping technology used in an effort to aid the reconstruction.**



Aerial shots of heritage sites and damaged areas taken by different agencies

- **2. Massive Flooding in Balkans, Bosnia 2014:**
  - Heaviest rain in 120 years – 1.5million people (40% population)
  - The **floods** caused damage and **landslides**
  - Brought landmines to the surface
  - **Deployed UAV with HD Camera and NiR Camera to identify the location of landmines displaced**
  - **Created 3D Maps and uses geo-statistical modeling to determine which direction land mines may have been displaced – declare as risk area**

ICARUS and partners setting up their multi-rotor UAV to inspect flooding. Credit: ICARUS.

Aerial image of flooded areas captured by the ICARUS UAV.

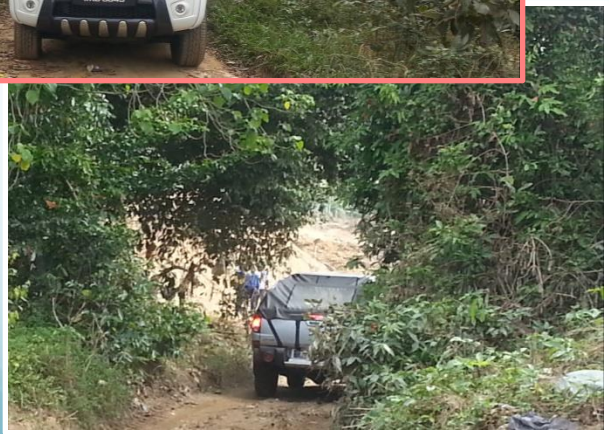
- **3. Typoon Haiyan in Philippines 2013:**
  - Devastated the city of Tacloban, Philippines in Nov 2013
  - **UAVs are used to map the country**
  - **Bring in UAV with a range of up 5km and high resolution video camera to assist humanitarian responders**
  - **UNTV has used drone technology to give speedy and accurate reports in the damages**

Soon after the thypoon

4. Massive Flooding in Kelantan 2015:

- UniMAP has executed a CSR in helping flood victims in Kelantan generally and focus on the people around Sek Keb Kampung Laut, Tumpat
- Using Falcon 8, COEUAS has come up with a concept of aerial mapping using DEM and simulation of flow and reservoir during flood for the purpose of the flood disaster prevention
- By analyzing the data and simulations, interested parties can determine which area will be affected when the water rise at a certain rate and prepare the appropriate counter measures that can be taken to overcome the problem of flooding

DATA ACQUISITION

Suitable Takeoff/Landing Base Identifications	Aerial Photography and Aerial Video Filming
 	   

Potential Humanitarian Uses

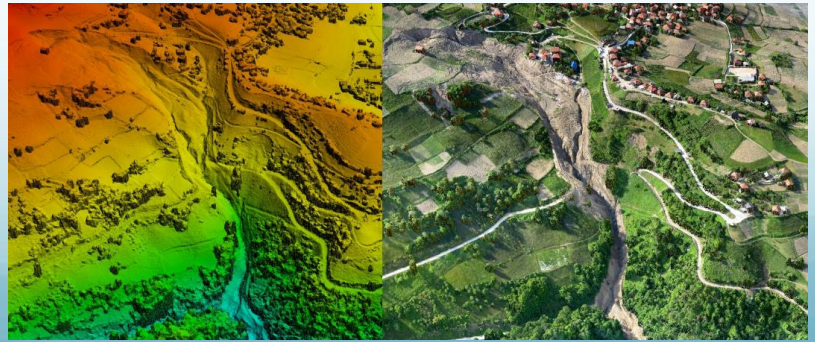
Humanitarian organizations started to use UAVs for data collection and information task that includes:

1) Real time information and situation monitoring

2) Search and rescue

3) Mapping

4) Transporter



1.Real time information and situation monitoring

- The most common use of UAVs is the provision of **high altitude video feed or photos**
- More sophisticated systems can broadcast a live feed directly over the internet
- These images can assist in task in humanitarian aid that include:
  - **rapid assessment of damage such collapsed buildings or blocked roads**
  - **monitoring distribution of goods, such as tarpaulins or tents**
  - **Identifying and analyzing temporary settlements or tracking displacement or movement of people**

2. Search and rescue

- UAVs equipped with infrared or other specialty cameras

3. Mapping

- UAVs can rapidly produce 3D maps that are often detailed and faster than satellite imagery
- The mapping enables improved logistics, awareness of informal communities, damage assessments, disaster risk reduction or early warning activities, agriculture monitoring to promote food security, flood monitoring, etc

4. Transporter

- Delivery small medical supplies, such as vaccines, food to the disaster zone that might otherwise be very difficult to reach

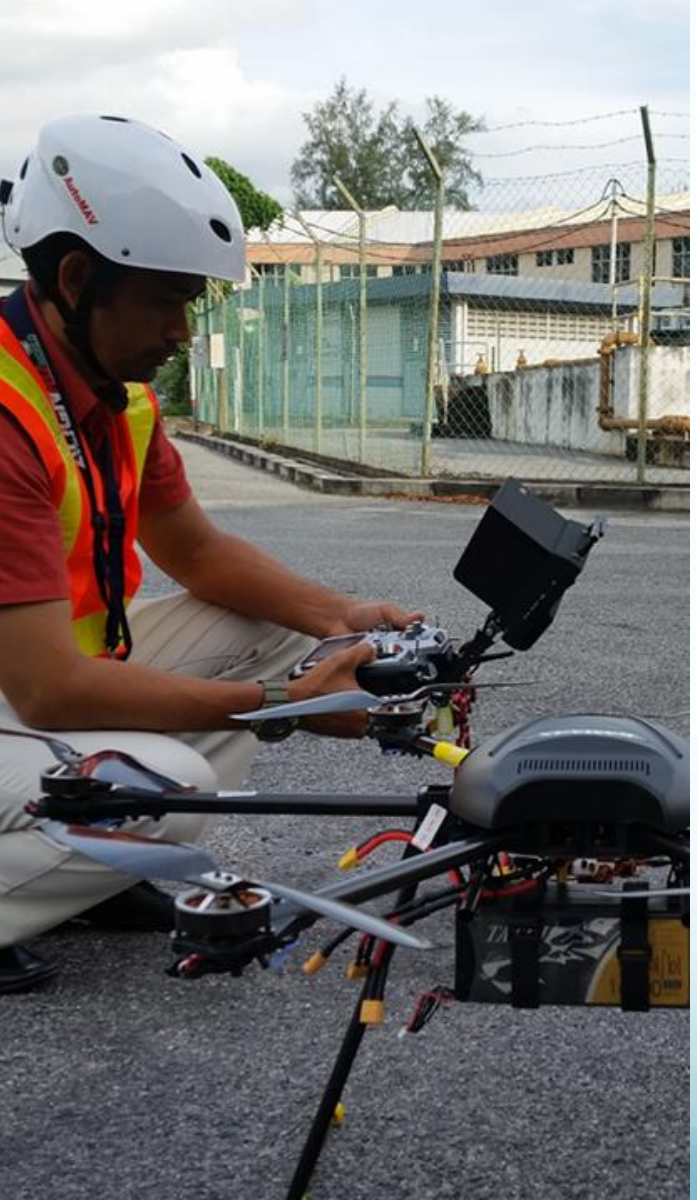
Challenges!

Multirotor Challenges!!

- Multirotor aerial robot is a **highly nonlinear**, **strongly coupled** and **under actuated system** because it has 6-DOF but only has 4 inputs

- **Payload carrying ability** – use only 50% of maximum propeller speed to generated the thrust for payload carrying ability, meanwhile the balance 50% use **to perform maneuverability**

- **Endurance flight time** – use speed of motor to perform flight task



Possible Solution

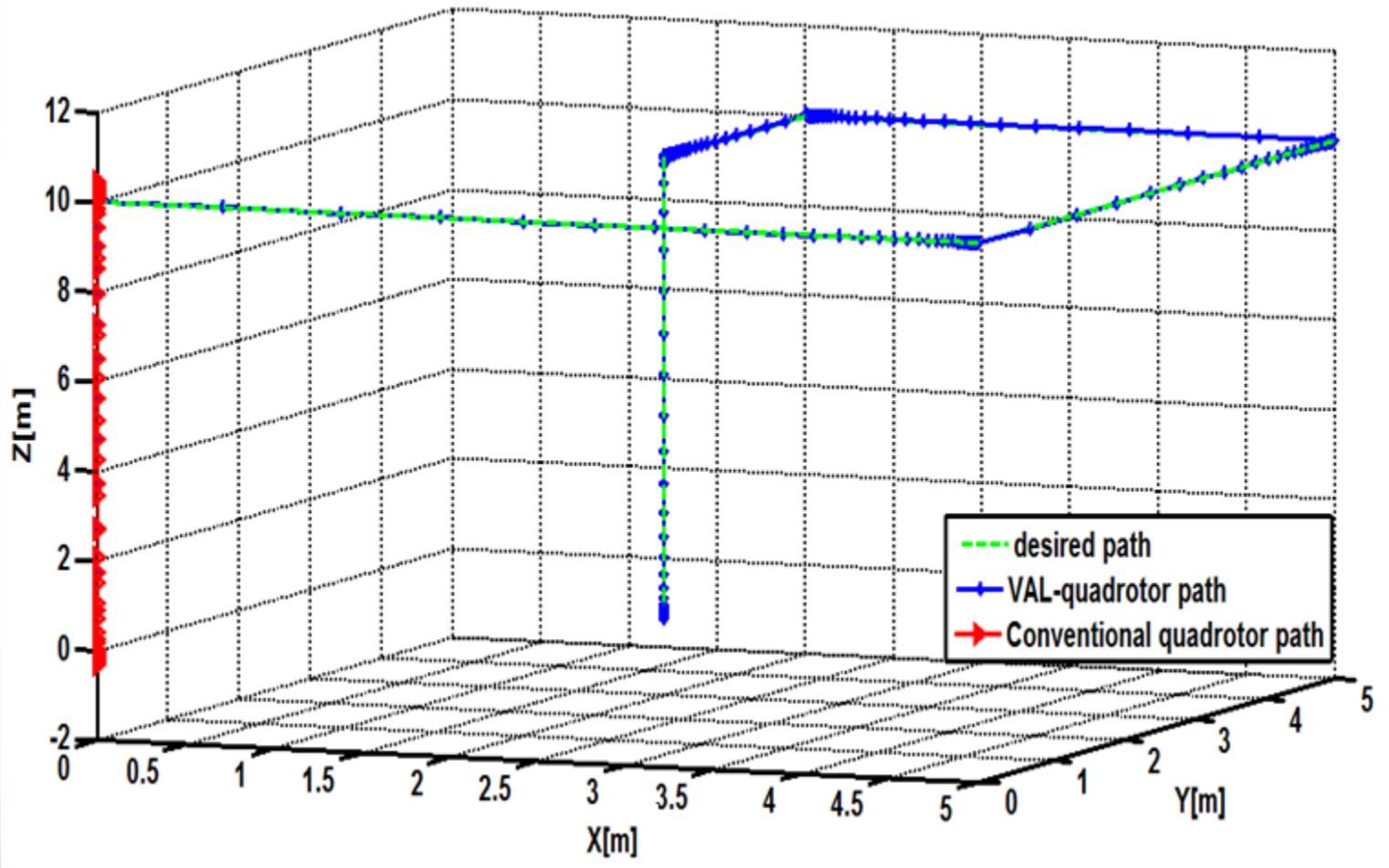
Variable Arm Length (VAL) Quadrotor

- The VAL-quadrotor exploits the torque around the axes **by varying the arms' lengths** in attitudes, x-, and y-positions **instead of the speed of motors.**
- Utilizes **all motor power** to carry more loads while using the arms' length to perform maneuvers.
- According to the proposed design, a mathematical expression is adopted for optimal choice of the arm's length

- VAL- quadrotor is considered a **linear control system** due to the design is based on the control input to the attitude system is by varying the arm length which is a function of first order system - **simple**

- Conventional quadrotor design is based on angular velocity = a second order system - **complicated**

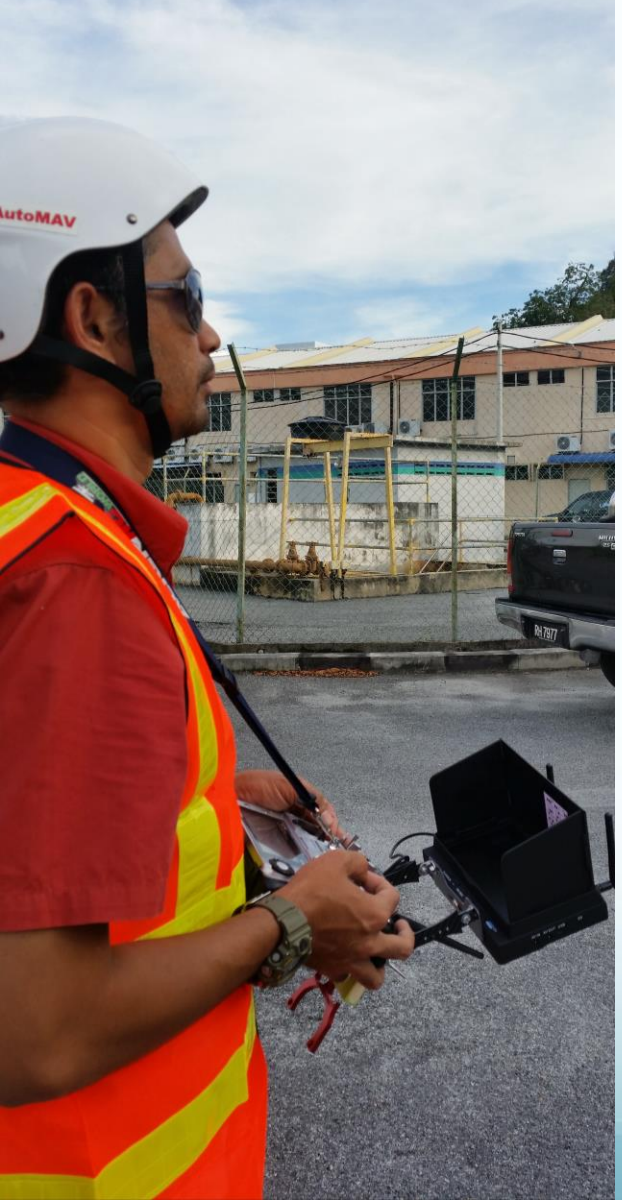
- Payload - thrust
- 500rad/sec are the max speed



Trajectory tracking according to the desired waypoints and followed by the response of conventional and VAL-quadrotor

Conclusion

- The VAL-quadrotor can improve the capability of payload about 40% extra of the standard quadrotor
- In normal case, VAL-quadrotor without carrying a load can increase the endurance time
- Val-quadrotor - Increase the life time of the motor since speed of the motor still constant during the flight time means the motor coil not affected by the thermal heating caused by increasing and decreasing the motor speed



With the capability to carry more payload make the VAL-quadrotor compatible with the future requirement especially in using for humanitarian aid activity

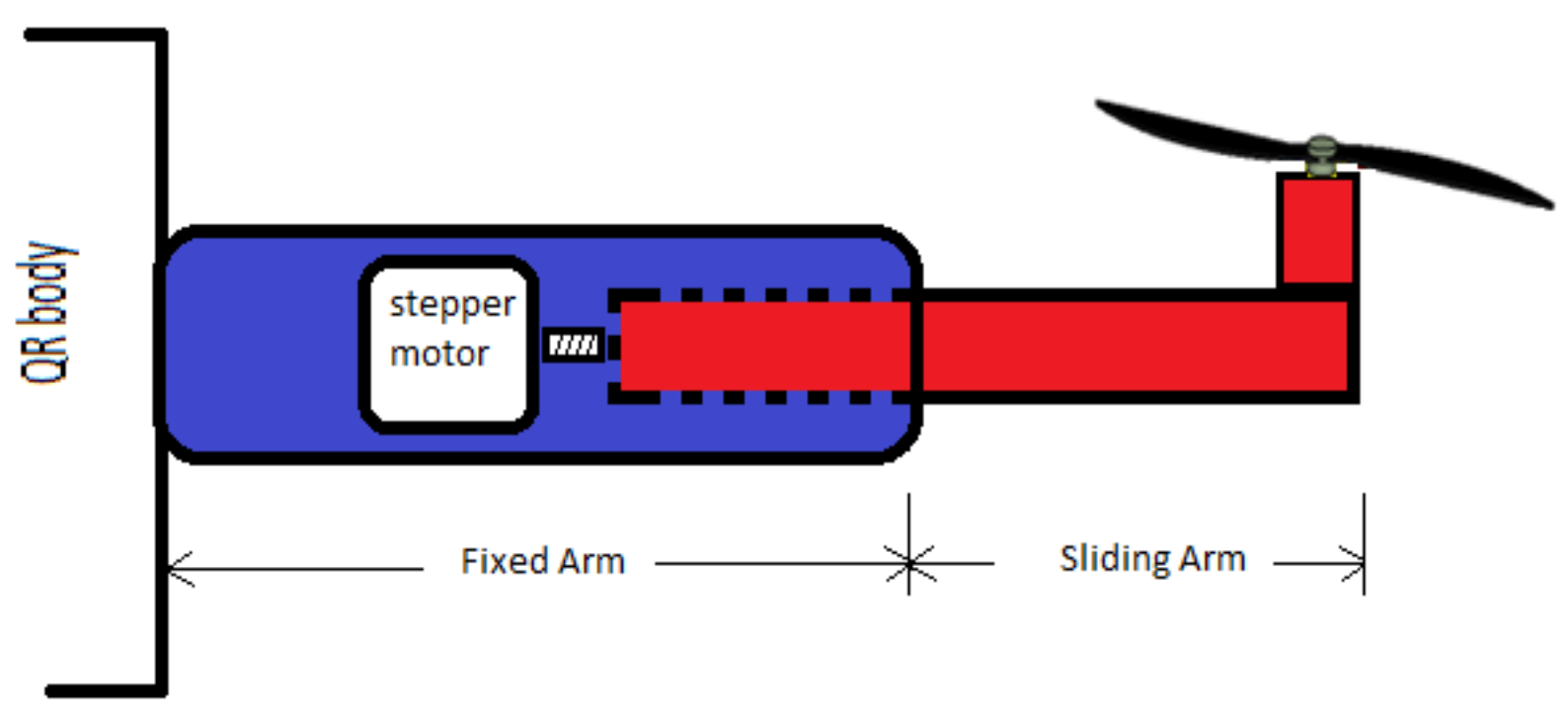
Other Challenges!!!

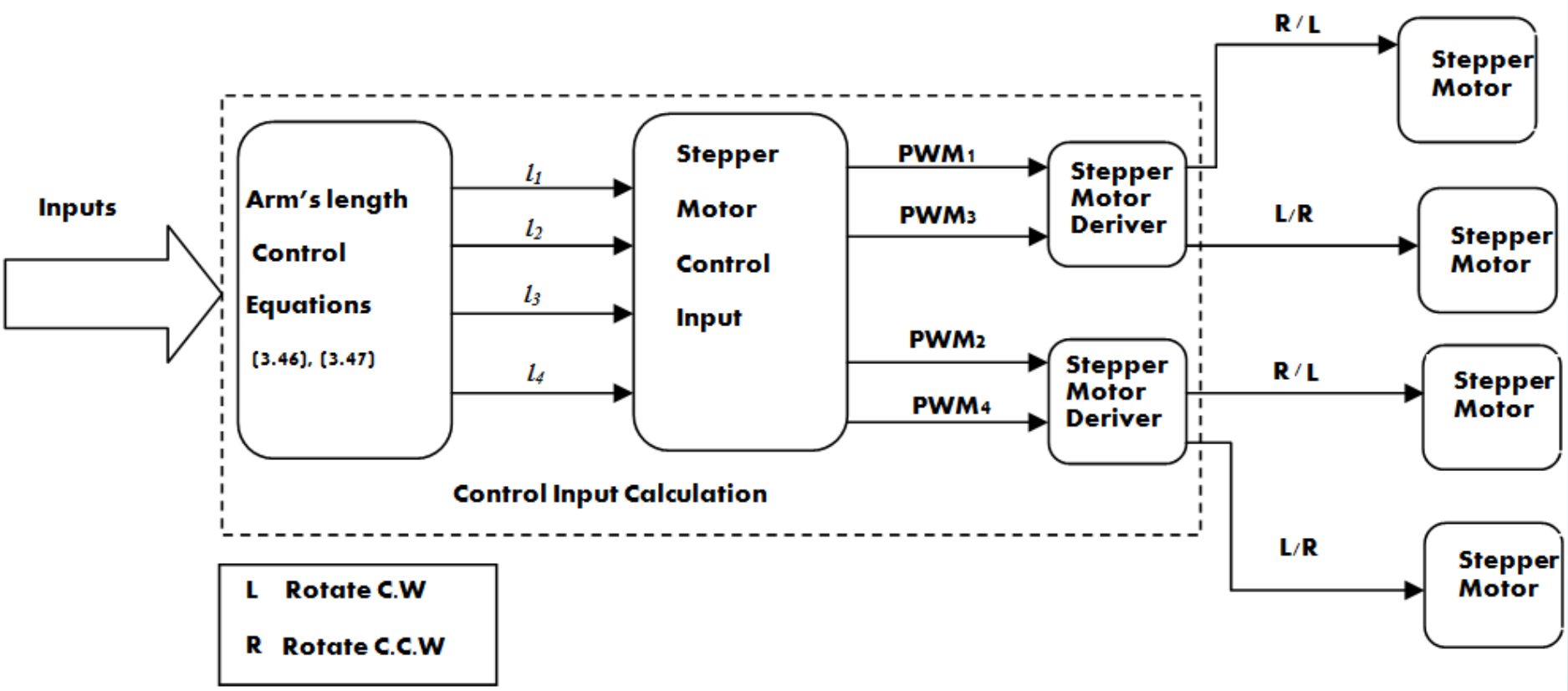
- Civil use of UAV is slackened by several factors:
  - Insurance issues
  - Lack of safe communication frequencies
  - Regulatory issues

THANK YOU

- Overview
- Example of UAV applications in humanitarian context
- Potential humanitarian uses
- Multirotor challenges
- Solutions
- Result and conclusion

Proposed arm design





Open loop block diagram of VAL-quadrotor arm's length control

Muddled between military and humanitarian activities

- Advanced mapping and imaginary ability, taken at disaster scene become an object of suspicion. Data could be abused if obtained by terrorist groups.

- Connection between humanitarian aid and political objective – example in Congo. UN used UAV to survey Congo's borders. They also use in combat. The **United Nations Organization Stabilization Mission in the Democratic Republic of the Congo** (MUNUSCO) wan to use those UAVs for humanitarian aid. Many International NGOs have decried this repurposing, claiming it muddies the waters between military and NGO activities.

European Union is funding ICARUS, a research project to develop unmanned search and rescue tools to assist human teams

Development of Cooperative UAS/UGV/USV tools for unmanned SAR

The EURECAT (previously known as ASCAMM) rotorcraft equipped with thermal imaging sensors demonstrated its operational capabilities in detecting victims and dropping rescue kits following a disaster.