On Emerging Technologies

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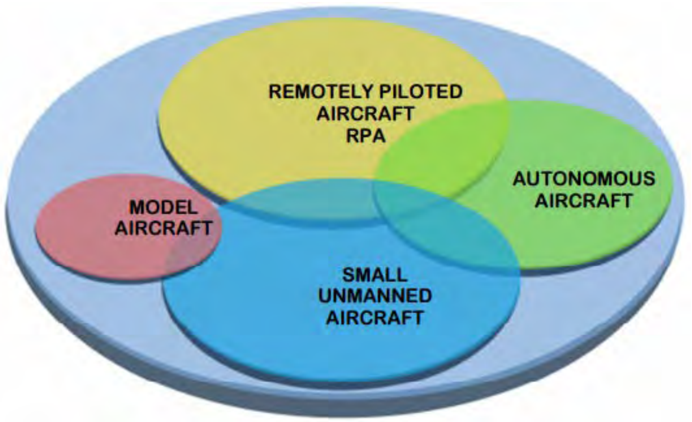
I. Overview

- **Recent emerging technologies in civil aviation**
  - **Advent of AI**
    - **Application to Civil Aviation**
    - **Certification of AI**
    - **Future of AI applications and adoptions**
  - **Legalization of UAVs**
    - **UAM and Beyond**



II. Advent of AI and Robotics

- Machine learning became very successful recently.
- Image classification is one of the most successful application of machine learning.
- Latest ML-based image recognition outperforms humans, which indicates AI will can do a vigilance for Detect-and-avoid task without getting tired or distracted.
- As with AlphaGo case, AI can make better strategic decisions.
- With its faster computing and enormous amount of data storage, an AI-powered autopilot can be of a great help for civil aviation.
- When not safety-critical, AI is adopted at a extremely fast pace.
  - iPhone’s FaceID, AI speakers, China’s facial ID system, and more

- **However, for civil aviation, where safety is of utmost importance, AI system cannot be simply introduced.**


Noname manuscript No.
(will be inserted by the editor)

ImageNet Large Scale Visual Recognition Challenge

Olga Russakovsky* · Jia Deng* · Hao Su · Jonathan Krause · Sanjeev Satheesh · Sean Ma · Zhiheng Huang · Andrej Karpathy · Aditya Khosla · Michael Bernstein · Alexander C. Berg · Li Fei-Fei

arXiv:1409.0575v3 [cs.CV] 30 Jan 2015

II. Advent of AI and Robotics

- Some insights on AI:

  - Deep learning-based approach is drastically different from previous AI systems.

  - Deep learning requires huge amounts of data: no data, no learning.

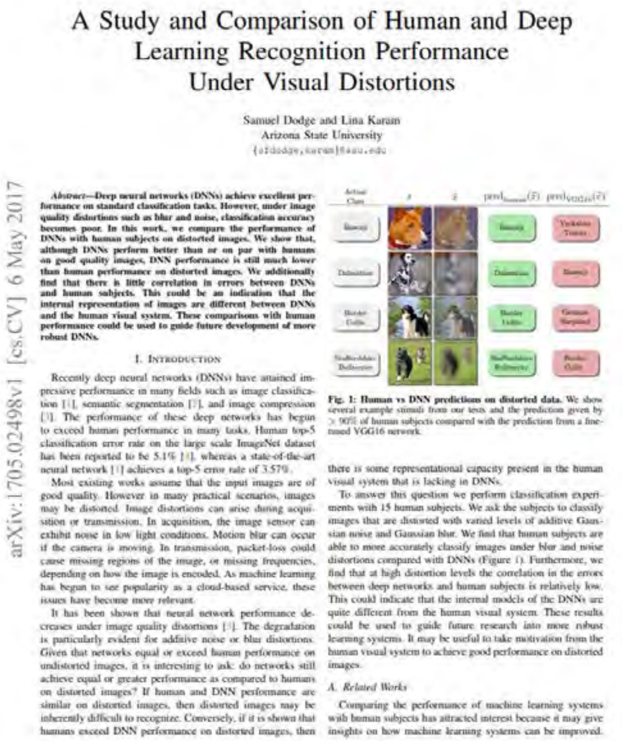
  - Currently, AI can be applied to relatively simple tasks such as image recognition.

  - AI does not constantly learn: typically learning is done offline as it takes tremendous amount of computing power.

  - It is true that the inner working of deep learning is not clearly known.

  - AI-based systems are different from adaptive systems.

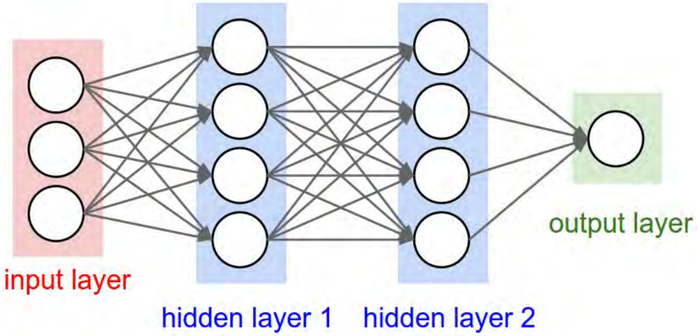
  - Deep learning based systems can be quite sensitive to small changes (brightness change, some disturbances in images)


A Study and Comparison of Human and Deep Learning Recognition Performance Under Visual Distortions

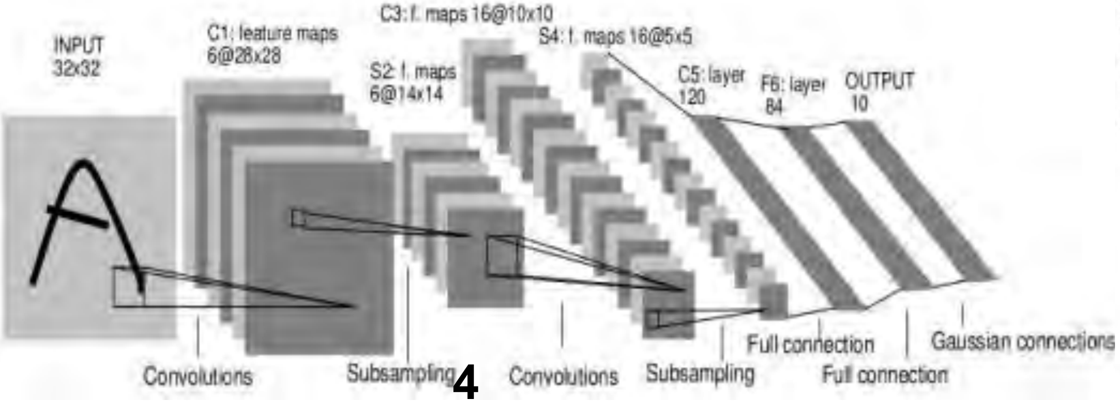
Samuel Dodge and Lina Karam
Arizona State University

arXiv:1705.02498v1 [cs.CV] 6 May 2017

I. Introduction



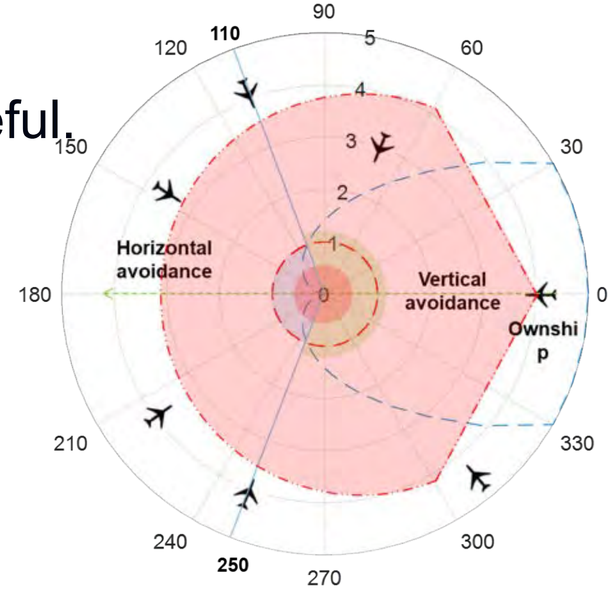
▲ Neural network example



▲ Convolutional neural network example

II. Advent of AI and Robotics

- Application of Deep Learning for Civil Aviation
  - When RPAS flies in VFR condition, visual detection can be very useful.
  - Being the best image classifier now, DL can be used for visual airplane detection for DAA
  - Using a large annotated set of data, a neural network can be trained for airplane detection
  - Using the latest GPU technology, a real-time detection can be performed.
  - There are a number of research activities on this topic, including my own lab's.
  - As an early result, the detection accuracy is not satisfactory, but there is a great potential for further improvement.



II. Advent of AI and Robotics

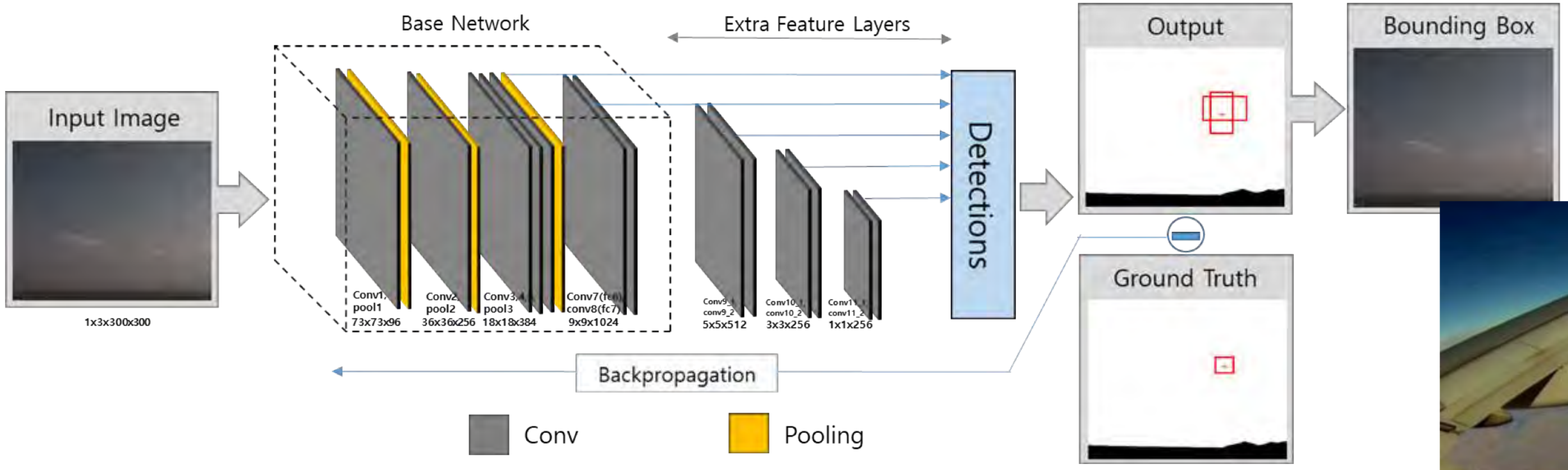
◦ **Modified SSD(Single-shot Detector) model for DAA technology**

- AlexNet-like base network: 7 convolutional layers and 3 max-pooling layers

- Modified : Less extra feature layers than that of original SSD but better speed and result

→ Original SSD model has 23 conv. layers but modified model has 13 conv. layers

- 88.19% detection success rate in positive frame while it tested using 17,651 frames



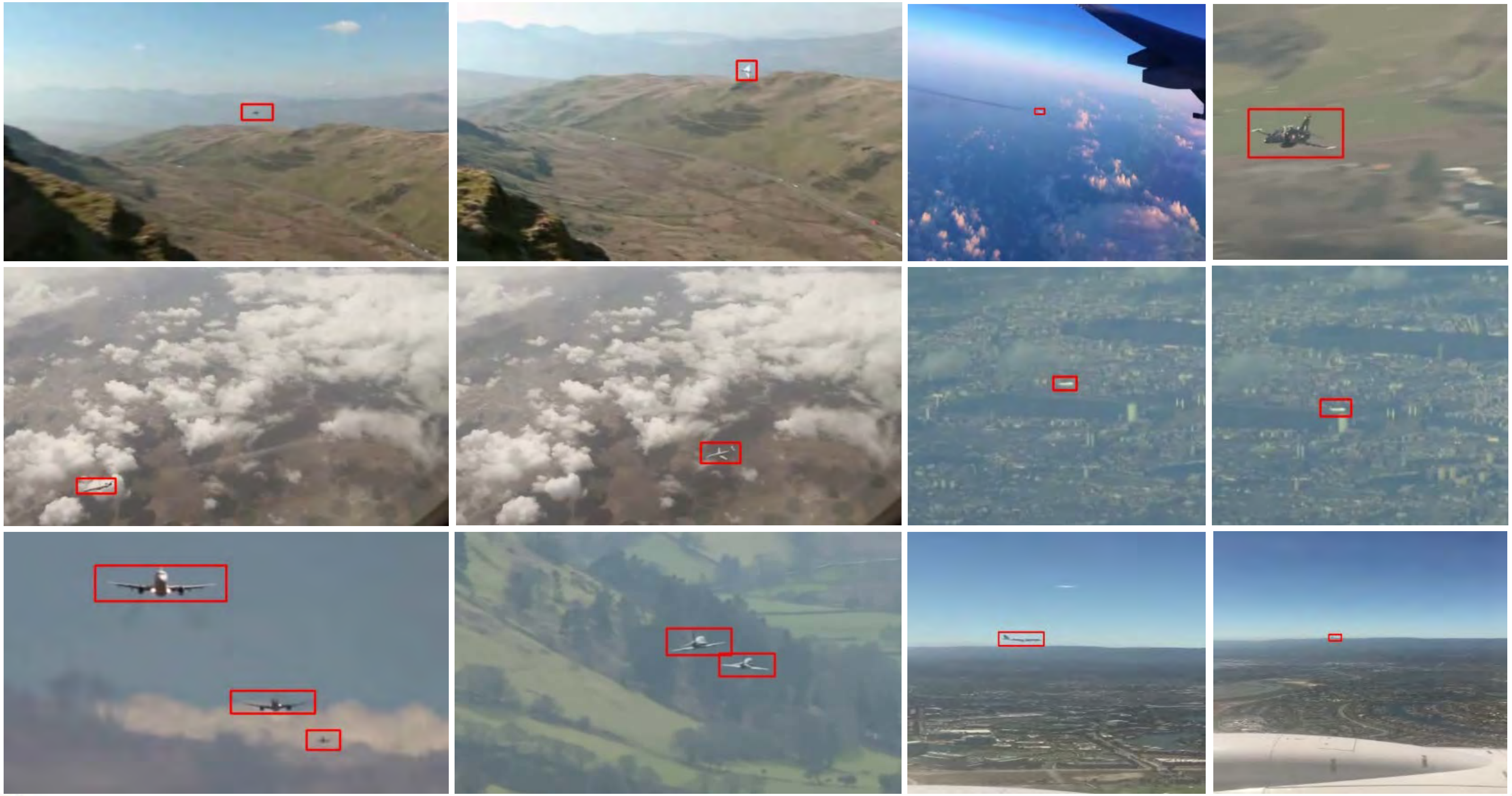
◀ **Modified SSD model And Learning process**

Number of Frames						Detected size	
Total	Positive	Negative	Detected	Missed	False alarm	Min	Max
17,651	7,984(45.2%)	9,667(54.8%)	7,041(88.19%)	943(11.81%)	205(2.6%)	28 px	29,666 px

ref) Hariharan, B., Arbeláez, P., Girshick, R., and Malik, J., "Hypercolumns for object segmentation and fine-grained localization," *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2015, pp. 447–456., Long, J., Shelhamer, E., and Darrell, T., "Fully convolutional networks for semantic segmentation," *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2015, pp. 3431–3440., Zhou, B., Khosla, A., Lapedriza, A., Oliva, A., and Torralba, A., "Object detectors emerge in deep scene cnns," *arXiv preprint arXiv:1412.6856*, 2014.

II. Advent of AI and Robotics

- Application of Deep Learning for Detect-and-avoid



II. Advent of AI and Robotics

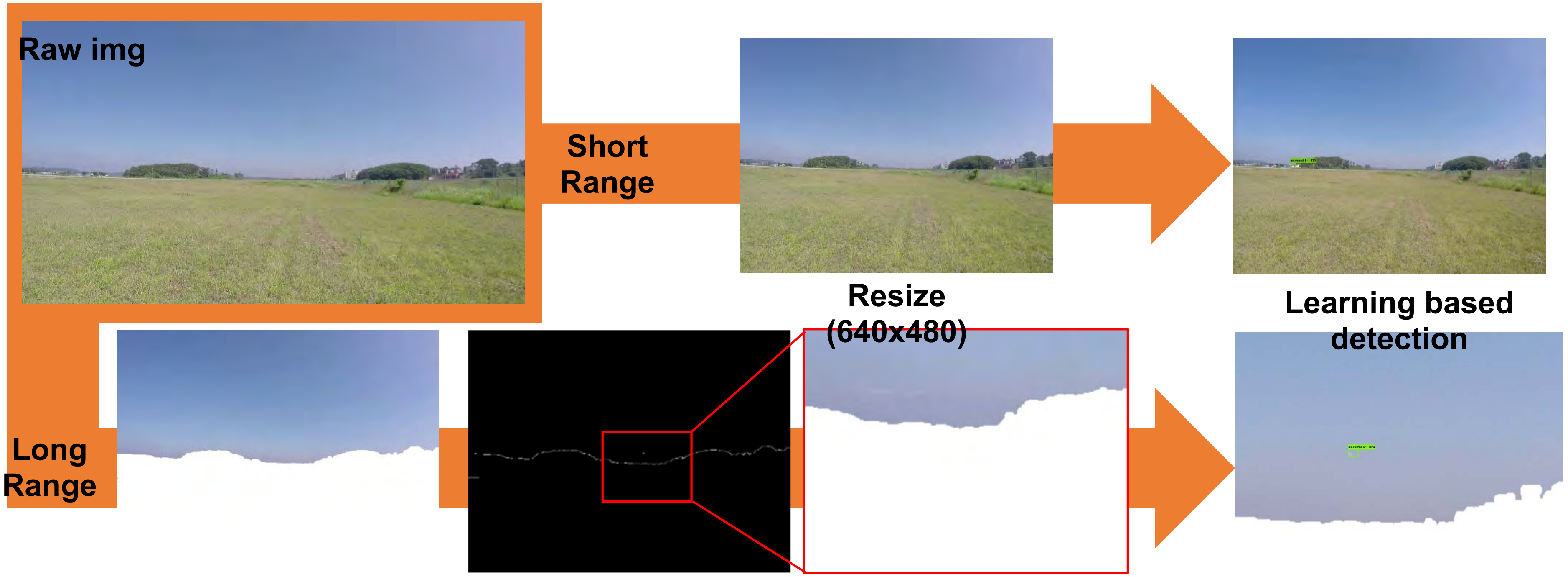
Further Improvement of learning based image detection for DAA

- Leaning based detection is highly depending on the shape of aircraft

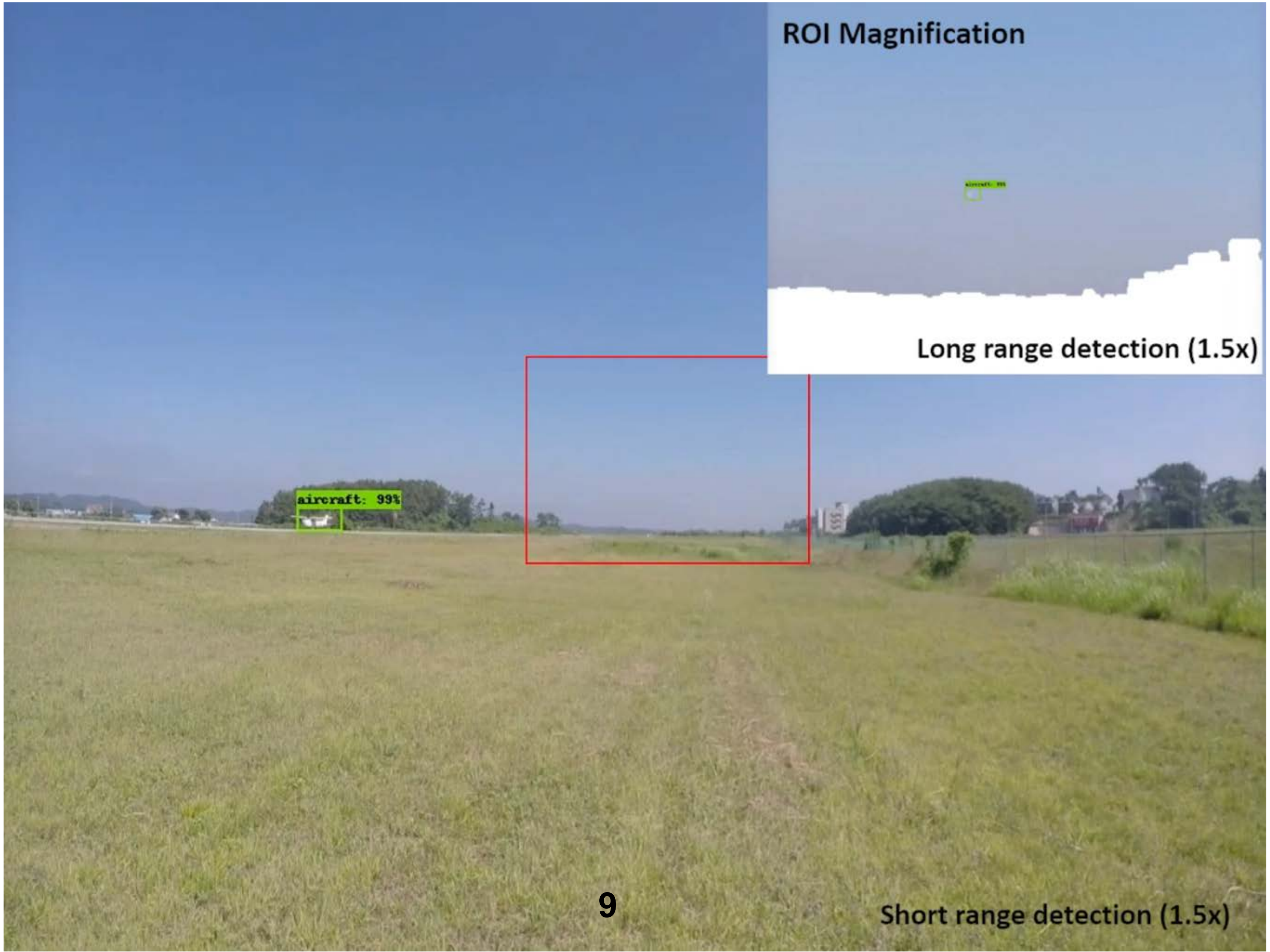
→ The shape should be clear enough : close and danger enough to see the shape

- Dot-like aircraft is difficult to be detected by learning based detector
- Distorted or blurred image is not suitable for learning based detector

Detect dot-like aircraft using ROI magnification and SSD using dot-like aircraft learning data

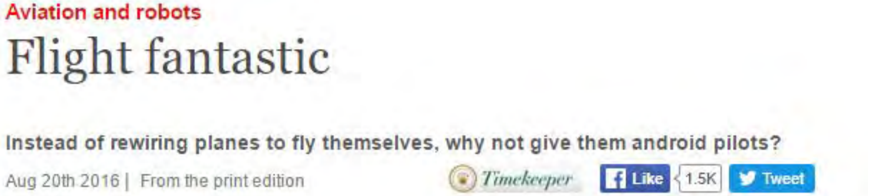


II. Advent of AI and Robotics



II. Advent of AI and Robotics

- Future of AI application to civil aviation
  - A highly automating autopilot can be developed
  - There are ongoing efforts. (DARPA ALIAS)



Aviation and robots

Flight fantastic

Instead of rewiring planes to fly themselves, why not give them android pilots?

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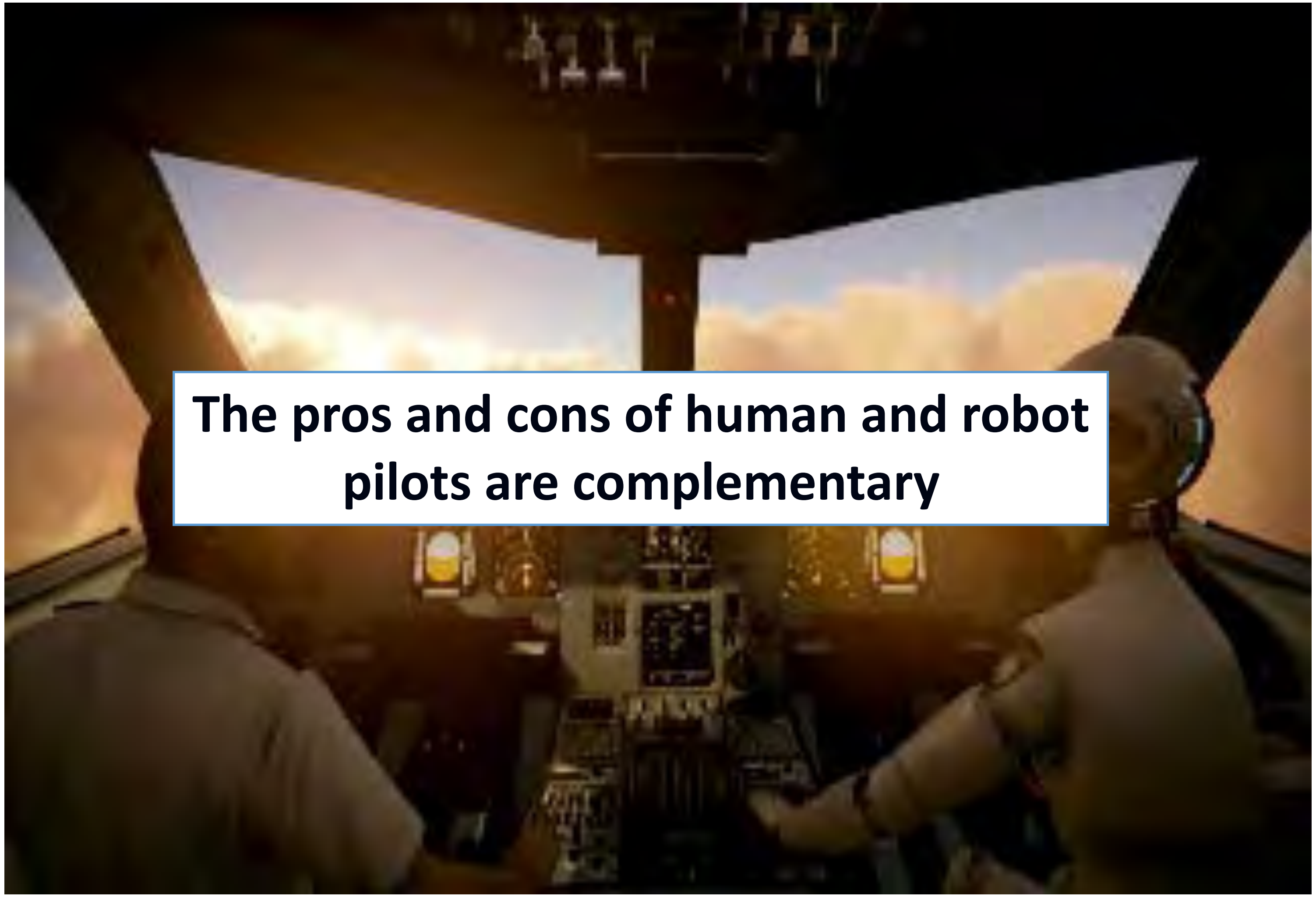
Agency:	Department of Defense	Release Date:	April 22, 2016
Branch:	n/a	Open Date:	April 22, 2016
Program / Phase / Year:	SBIR / Phase I / 2016	Application Due Date:	June 22, 2016
Solicitation:	DoD SBIR 2016.2	Close Date:	June 22, 2016
Topic Number:	AF162-D003		

II. Advent of AI and Robotics

Human Pilot
Flexible, Adaptive
Hard to retrain
Existing rules and systems are made for humans
Can make mistakes (physical and mental causes)
Job issues
Very long time to train. Hard to ”transfer” knowledge and experiences



The pros and cons of human and robot pilots are complementary

Robot Pilot
Not flexible nor adaptive (for now)
Easy type conversion
Hard to integrate
Follows programs without error
Have extremely large memory, easy to update
Can directly talk to avionics
Can compute very complex equations
Not tiring (no loss of vigilance)
Easily manufactured and duplicated

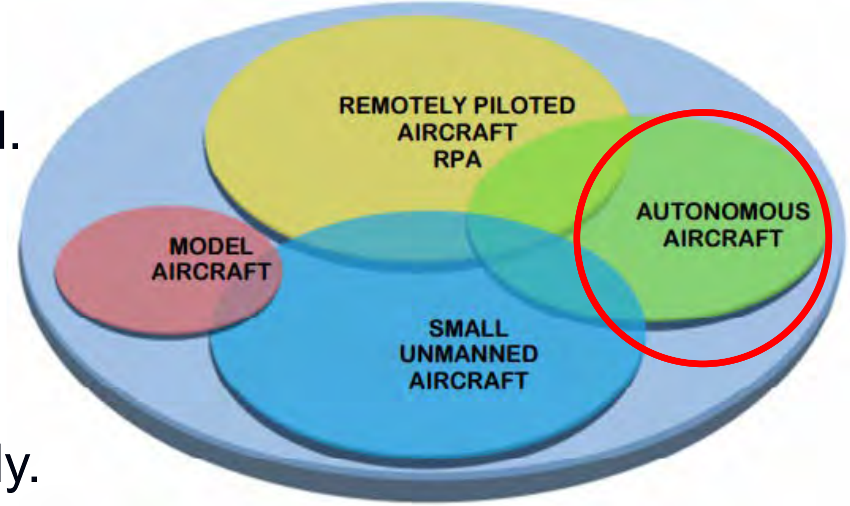
II. Advent of AI and Robotics

- Future of AI application to civil aviation
  - It need a long time before the adoption, but it is certainly an intriguing direction.
  - A robot pilot will be a great help.
    - Using its large memory, it can memorize entire Jeppesen chart.
    - Using data communication, it can directly “talk” to avionics.
    - Using voice communication, it can converse with pilot (hopefully better than today’s AI speakers)
    - Using hands and feet, it can manipulate all the levers, switches, yokes, pedals and so on without any modification.
    - Using its vision, it can recognize the cockpit and outside of the window.
    - Using its own sensors, it can estimate the motion.
  - **It is not wise to to replace human pilots, but to complement.**

III. Beyond of UAVs

- "Manned Drone"
  - Combining RPAS and UAS, "manned drone" can be developed.
    - There always have been demands for ultimate air mobility
  - Just like self-driving cars, "manned drone" will be operated without passenger's help

    →Currently, RPAS is not allowed to operate autonomously.
  - Many "silicon-valley" style companies are suggesting Urban Aerial Mobility (UAM)
    - Google, Uber, Ehang, Airbus, and more.
  - While safety is the utmost concern of civil aviation, legislation is not a simple task.

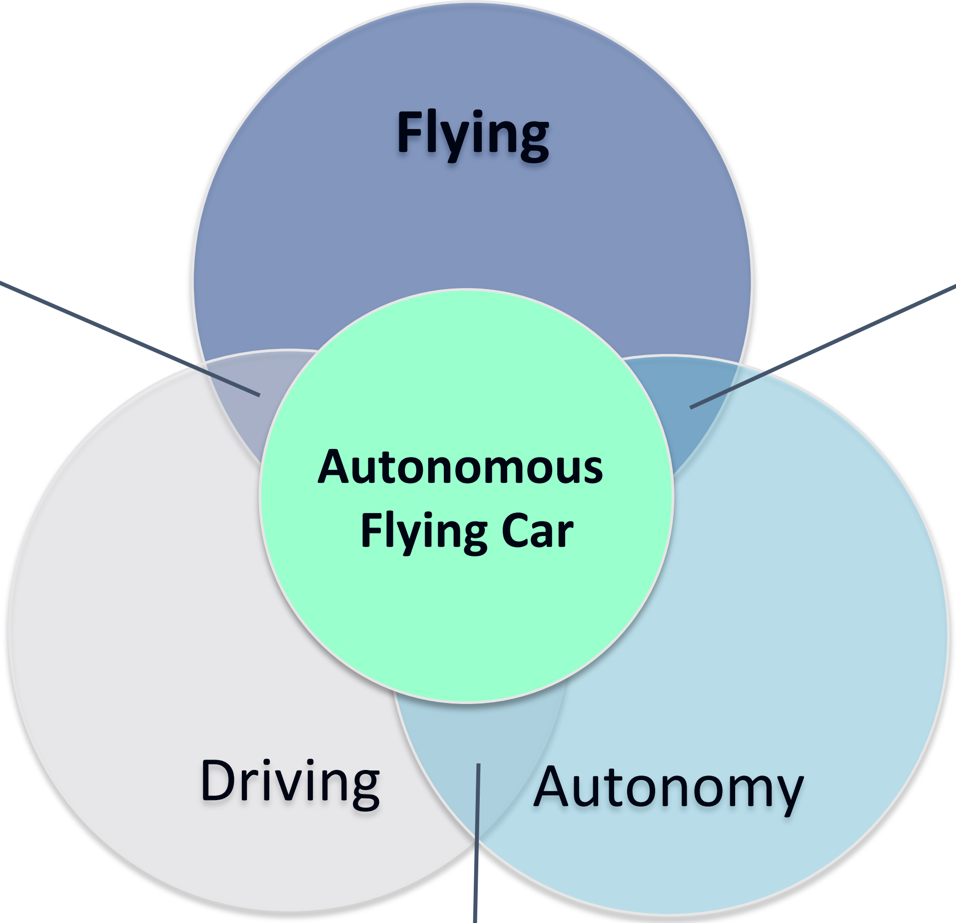


III. Beyond of UAVs

- Comparison of UAV and Self-Driving cars

		
Technological Status	Almost fully developed (except C2 and DAA)	Not yet ready
Risk level	Catastrophic to passengers if onboard and any people and property on ground	Can be fatal (but mitigated) to passengers and along the path. No indiscriminative.
Contributors	Aircraft Companies	Automotive Companies and IT Companies
Regulations	Driven by ICAO, JARUS, and states	Not yet much discussed
Target Date	RPAS: 2024	2020+ (step by step)
Major Challenge	Safety, global harmonization	Technology itself.

III. Beyond of UAVs



Flying Cars
(by human pilot/drivers)

Autonomous Car
(human passengers, driving autonomously)

Drone Taxi
(human passengers,
flying autonomously)

IV. Closing remarks

- Recently, UAS are prepared for integration into civil airspace.
- RPAS is almost ready (2014), UTM is being studied, UAM is being “invented”.
- Recent advent of machine learning-based AI is making huge impacts everywhere.
- Machine learning can be used for many applications in civil aviation, most notably vision-based detection of other aircraft in VFR condition.
- A robot powered by latest AI can be developed to aid human pilot
- Machine learning-based system requires different way of certification.
- It takes a VERY LONG time to prepare regulation for any new technologies, not fast enough to meet the expectation of “silicon-valley minds”.
- Aviation authorities should find some ways to become faster to keep up with technology advances *without compromising safety in civil aviation.*