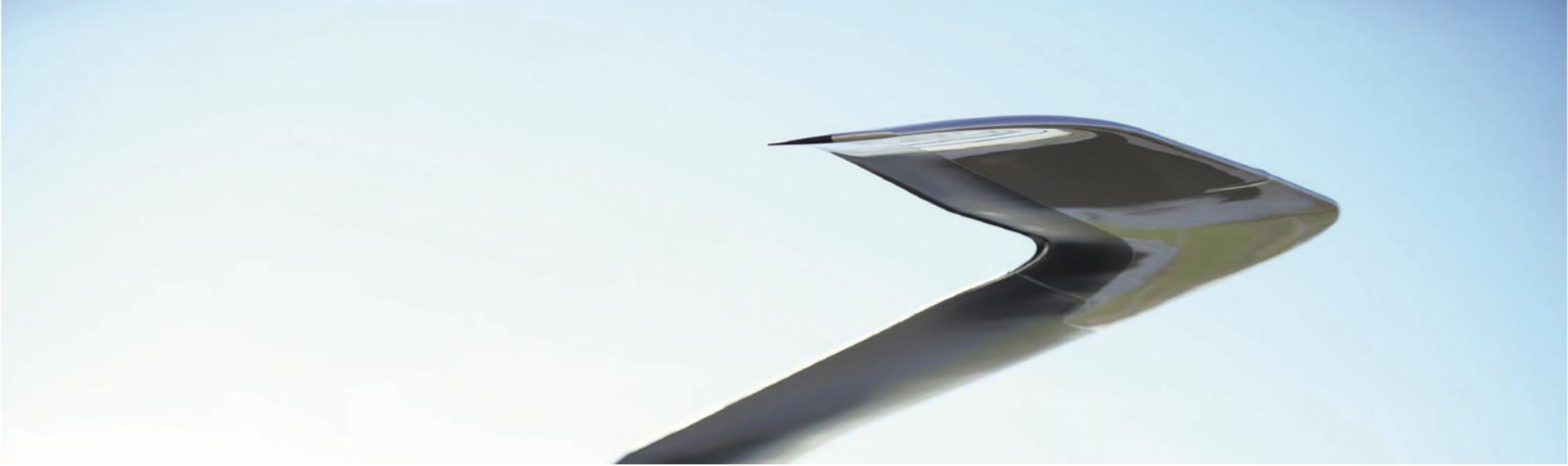


HELICOPTERS

Intelligence Artificielle dans l’aviation

Tomasz Krysinski & Kamila Debska

30 juin 2020

AIRBUS

Tomasz Krysiński
Directeur de la Recherche et de l'Innovation
Airbus Helicopters

Kamila Dębska
R&T Program Manager
Airbus Helicopters

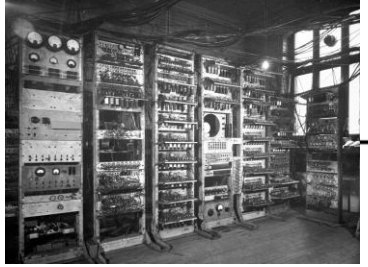
Henryk Zygalski

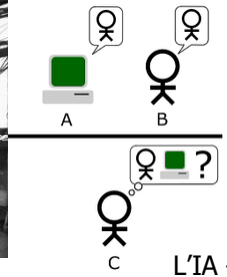
Marian Rejewski

Jerzy Różycki

Les trois polonais à l'origine de la première attaque cryptanalytique sur la machine de chiffrement Enigma au début des années 1930

l'Université de Poznań





Turing invente le concept de machine universelle

Test de Turing

L'IA – domaine de recherche (conférence de Dartmouth)

Création d'ELIZA, le premier agent conversationnel

Les systèmes experts

1937 **1950** **1956** **1963** **1982**

IA SYMBOLIQUE

1948

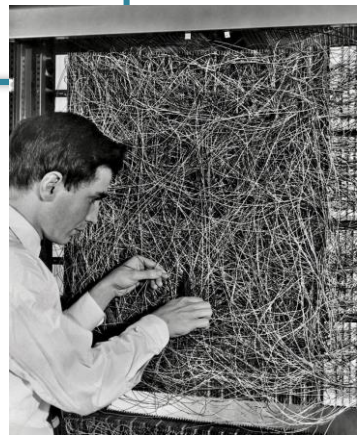
Fabrication du premier ordinateur

CONNEXIONNISME

1943 **1957**

McCulloch et Pitts inventent le neurone artificiel

Rosenblatt crée le Perceptron, l'un des premier réseau de neurones artificiels monocouche



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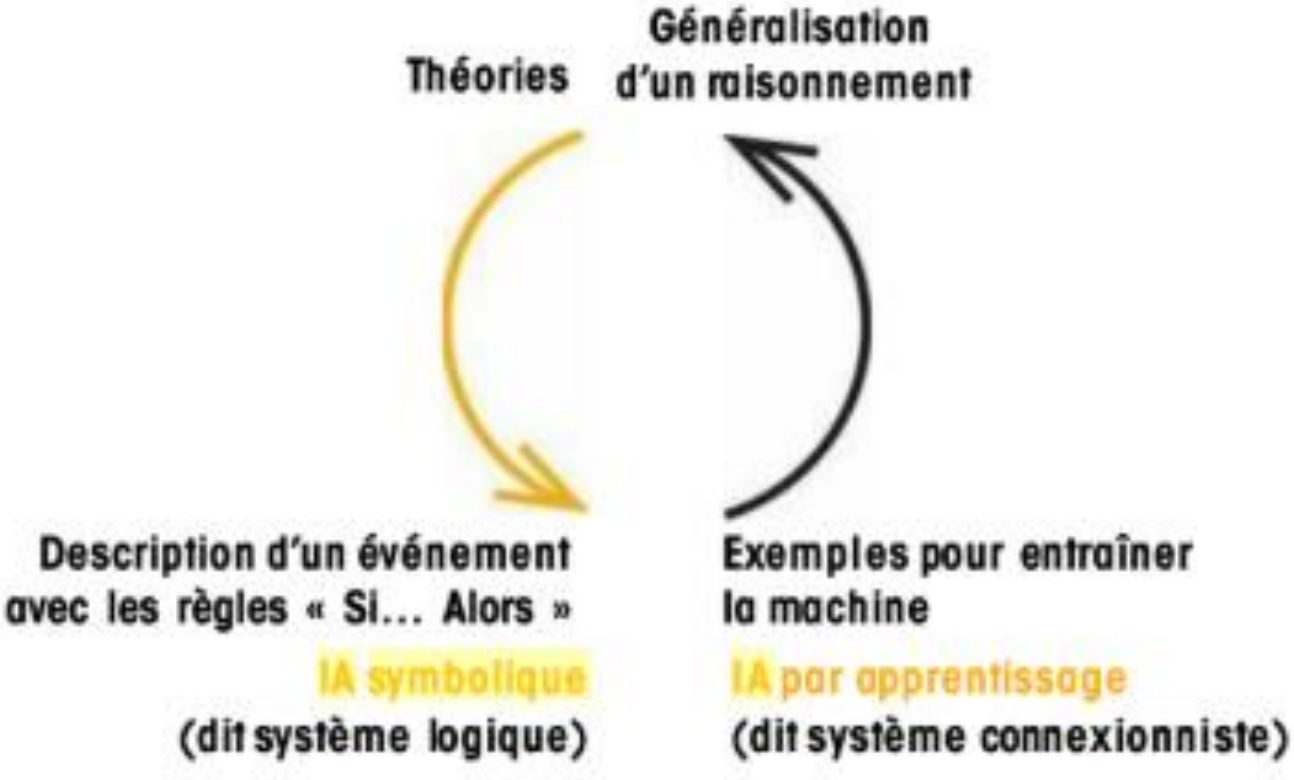
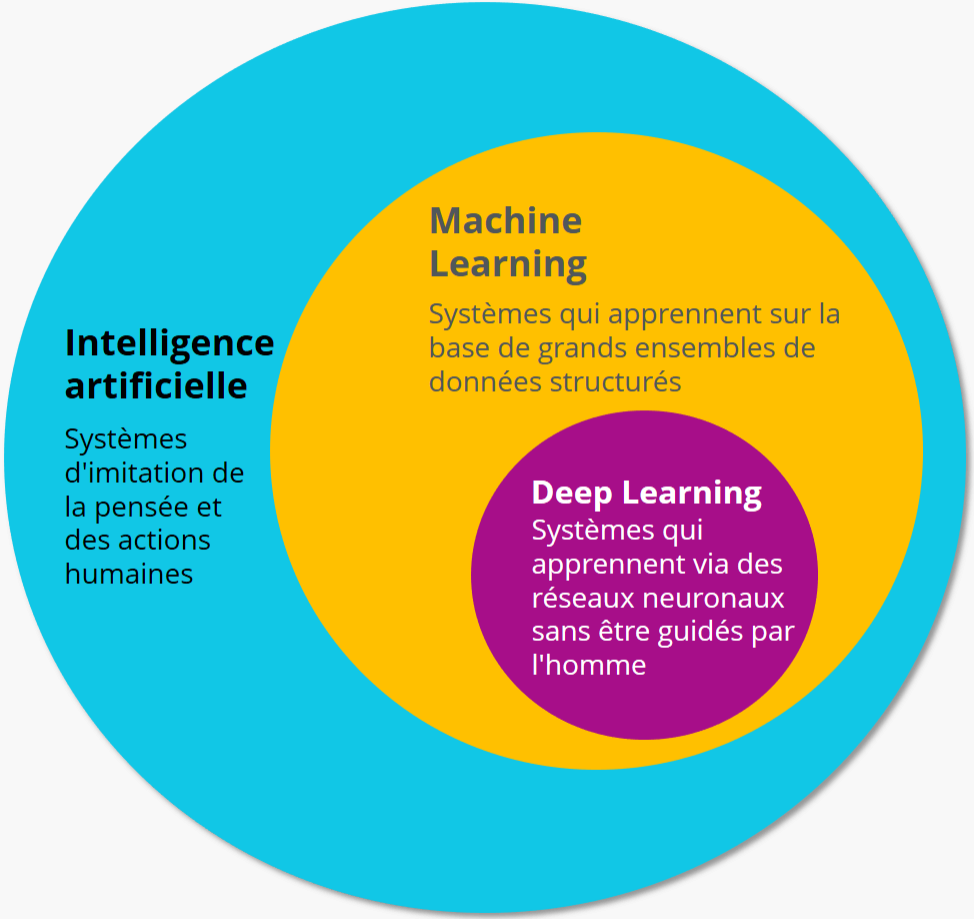
Deux courants de l'IA



Qu'est-ce que l'intelligence artificielle ?

"La capacité, conférée par les humains aux machines,
de mémoriser et d'apprendre sur la base de l'expérience,
de penser et de créer, de parler, de juger et de décider"

Quelle est la différence?



« Je pense que l'IA est bien plus dangeureuse que l'arme nucléaire »
Elon Mask, PDG DE SPACEX et DG DE TESLA

« Il n'existe pas tant de technologies dans le monde qui soient à la fois aussi prometteuses et aussi dangeureuse »
Bill Gates, Cofondateur de MICROSOFT

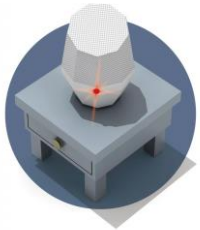
« L'intelligence artificielle promet de créer une économie plus productive et efficace. Si elle est bien exploitée, cela peut générer énormément de prospérité et d'opportunités »
Barack Obama, Président des Etats-Unis

L'intelligence artificielle sera partout, comme….

Finance

Santé

Commerce



Assistant personnel

Environnement

Industrie

Défense

Transport aérien et automobile

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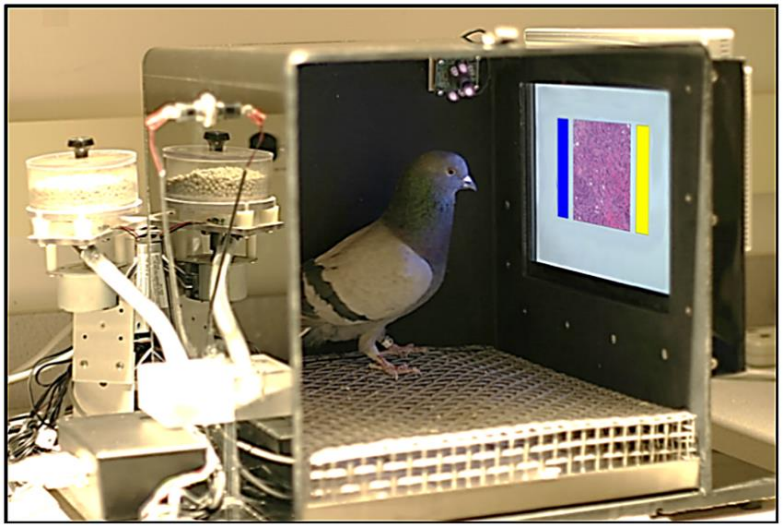
Biological Neural Nets

Pigeons as art experts study driven by (Watanabe *et al.* 1995)

- **Experiment:**
  - Pigeon in Skinner box
  - Present paintings of two different artists Monet and Picasso
  - Reward for pecking when presented a particular artist

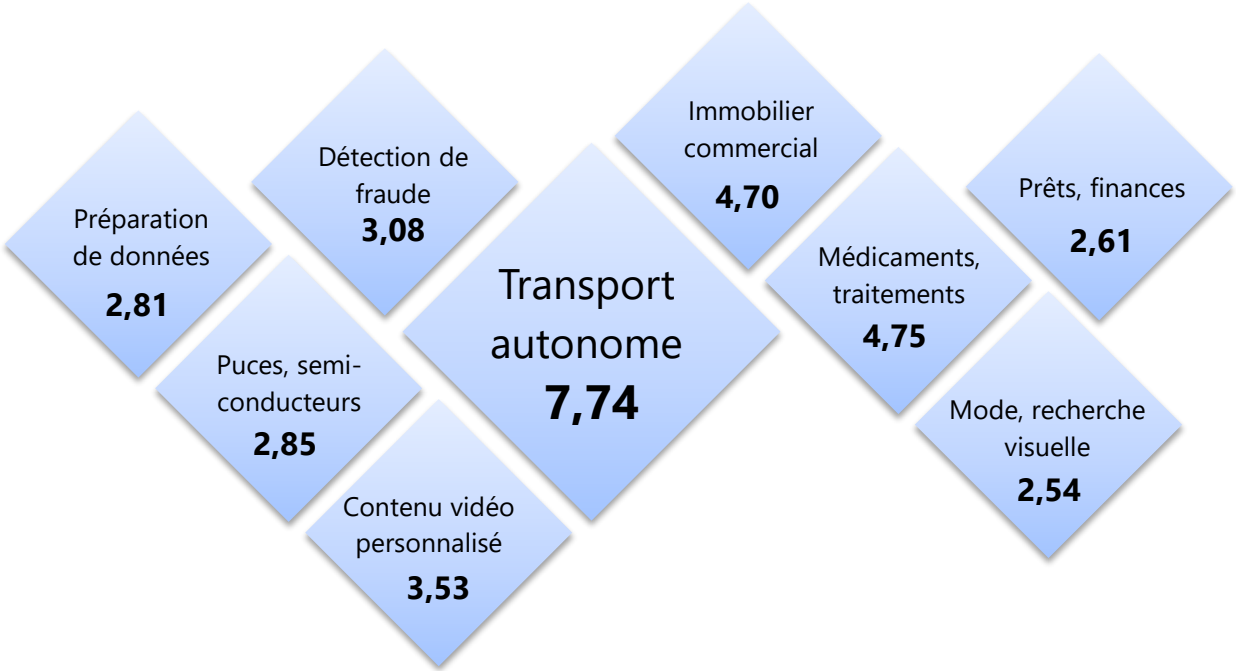


Picasso

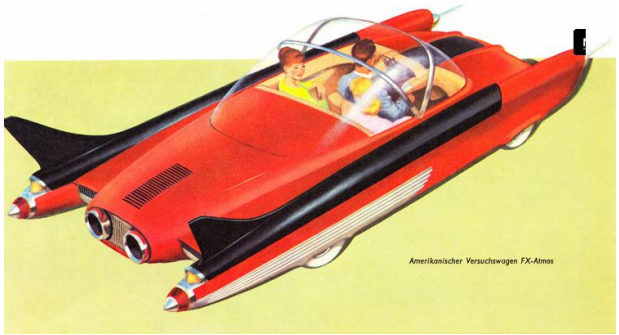
Monet

La voiture autonome, application de l'IA la plus financée (en milliards de dollars) -

top 10 des investissements privées en 2018

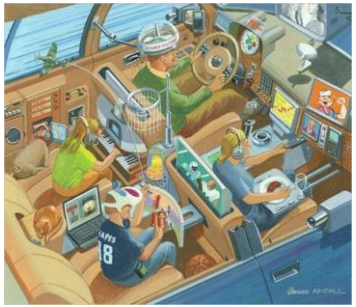


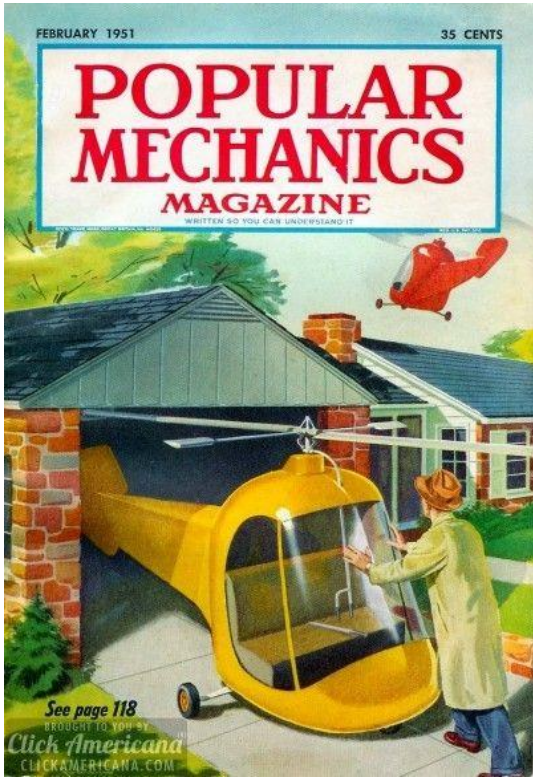
We always dreamed about autonomous vehicles



München · Ideen zu unserer Zukunft **1941**

Zukunftsstadt aus der Sicht von Hans und Botho von Römer im Jahr 1941. Foto: Deutsches Museum





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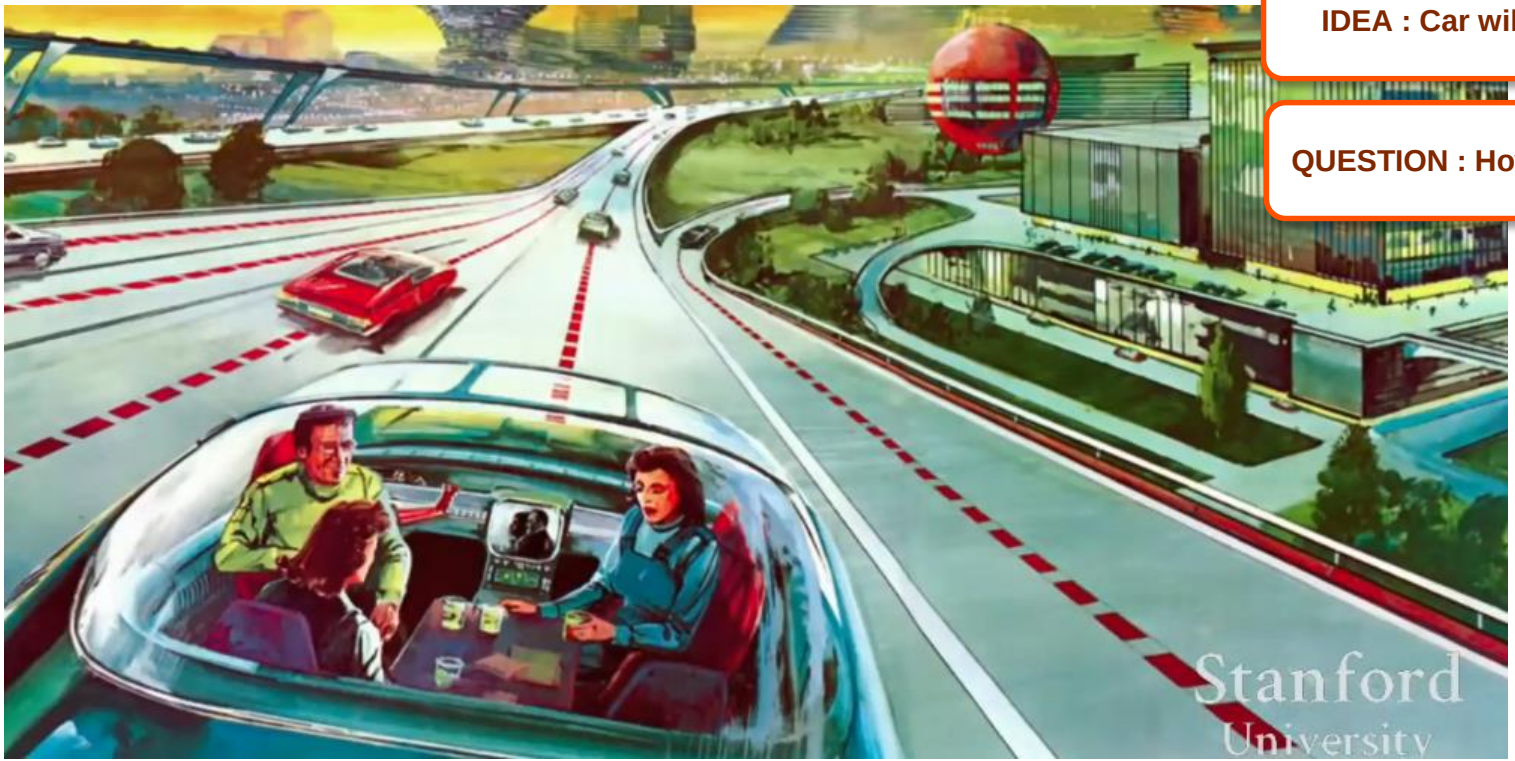
US

What will the autonomous cars look like ?



IDEA : Car will be self-driving

QUESTION : How real is it today ?

What is an autonomous cars / VTOL ?

Automobile **VTOL**

Pilot liability

TODAY

0	No automation		There are no autonomous features 	
1	Drive assistance		traffic jam assistant, Park Assistant… 	**PA, RSAS, ROD RADAR** 
2	Partial automation		TESLA autopilot Drivers must monitor and react 	**SENSE & AVOID: EAGLE + PA** 
3	Conditional automation	**Requires human driver backup** You don't need to monitor but you need to be there		**Advanced Autopilot**

OEM liability

4	High automation	System can cope with all situations automatically in **a defined use case**		**Manned autonomous vehicules**
5	High automation	**No human driver required during all journey**		**Unmanned autonoumous vehicle (UAV)** 

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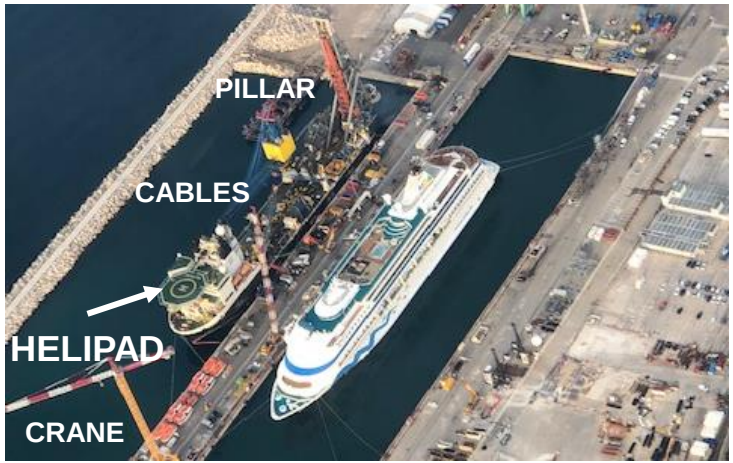
l’autonomie de voiture vs l’autonomie d’hélicoptère



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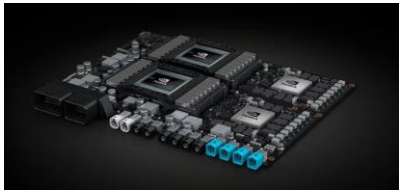
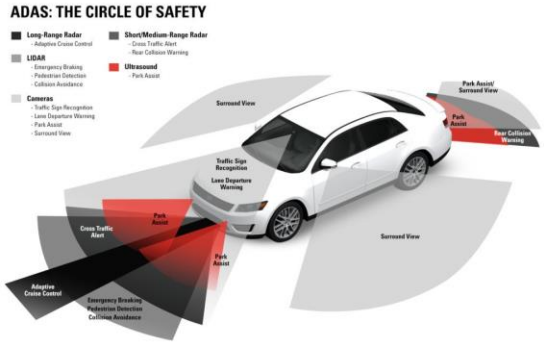
Comment l’intelligence artificielle s'impose au cœur de l’automobile

Les capteurs et algorithmes, les cinq sens de l'IA



Cloud et maintenance prédictive



Au service du bien-être du conducteur et de ses passagers

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Comment l’intelligence artificielle s'impose au cœur de l’hélicoptère

Situational Awareness

Transform interaction Pilot / Helicopter

Provide Options & Services

Improve Avionic Architecture

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Situational Awareness

https://www.dailymotion.com/video/kSDPpLwbpjOgqVw72JB

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Provide Options & Services

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Provide Options & Services

HUMS

"Health Usage & Monitoring Systems"

Optimize Maintenance Cost

- Customizable maintenance
- « ON-condition » maintenance
- Live Damage → Adapted DDU
- Relief of direct maintenance

Improve SAFETY

- Detect Catastrophic Failure
- Detect Unusual Degradation

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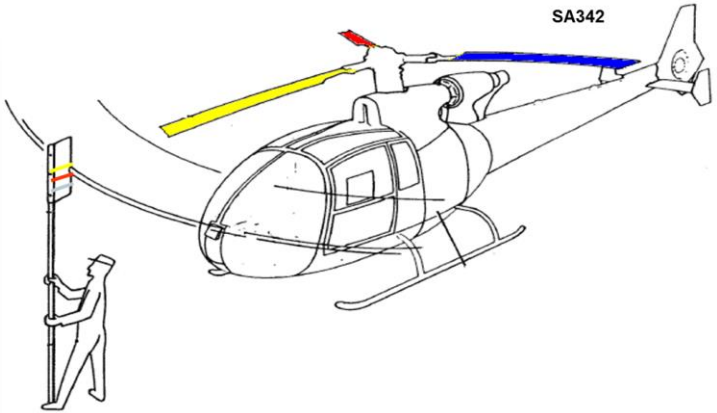
Rotor Track & Balance methods



1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s

Flag and crew feeling

Mass tuning: by iterations based on the crew feeling of cabin vibrations.
Pitch control and Tab tuning: Blade tracking identified with paint on blades and a white flag (ground run only !)

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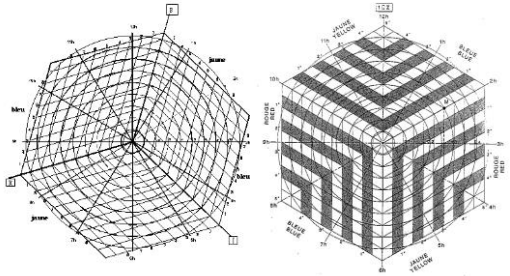
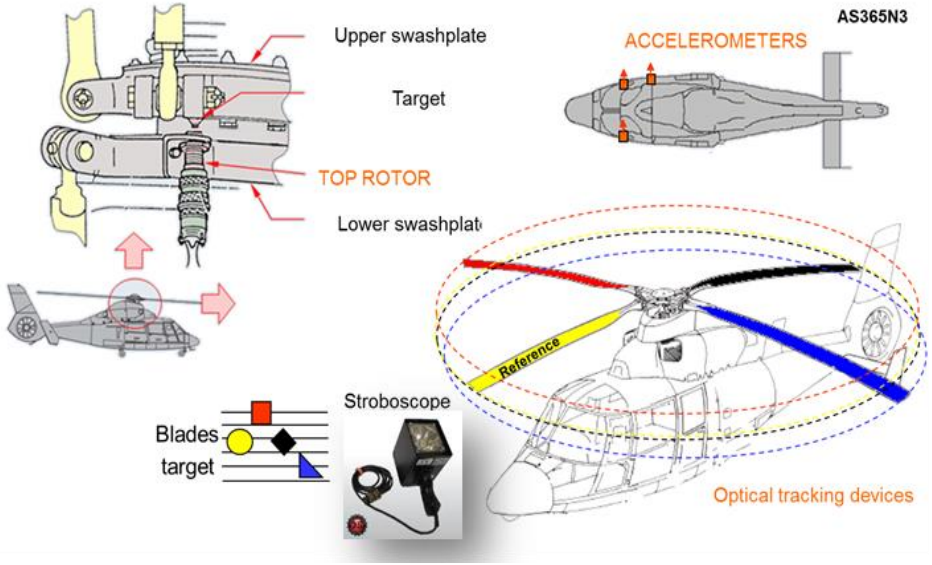
Rotor Track & Balance methods



Abacus mass Abacus tabs



Accelerometers + strobe light

Corrections given by abacus on paper

Manual optimisation of track and vibrations

Required sometimes many iterations

1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s

Flag and crew feeling

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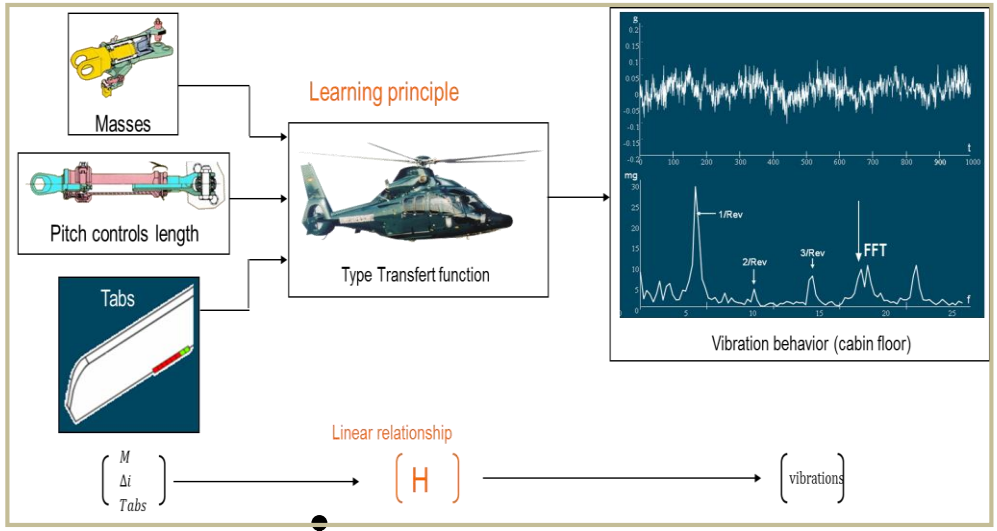
Rotor Track & Balance methods



Accelerometers + strobe light

Corrections given by abacus on paper

Manual optimisation of track and vibrations

Required sometimes many iterations

STEADYCONTROL® Rotor

AIRBUS HELICOPTERS INNOVATION

1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s

Flag and crew feeling

Mass tuning: by iterations based on the crew feeling of cabin vibrations.

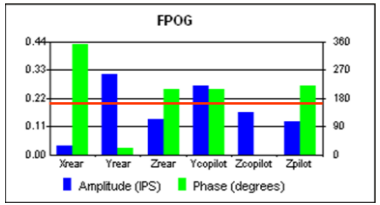
Pitch control and Tab tuning: Blade tracking identified with paint on blades and a white flag (ground run only !)

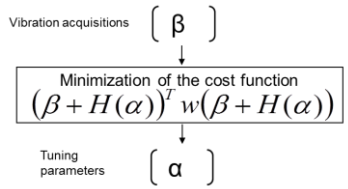
Neural network: Automatic method

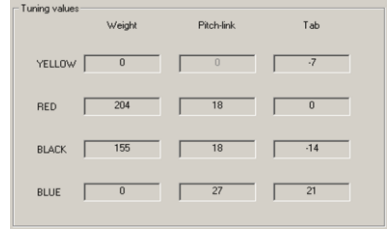
One shot tuning (1 acquisition flight + 1 Verif. flight)

No track checking (optimisation for automatic track alignment)

No specialist required (Easy interpretation)







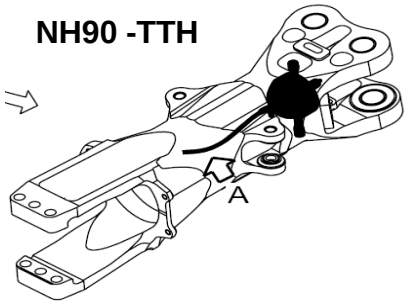
HELICOPTERS

Rotor Track & Balance parameters

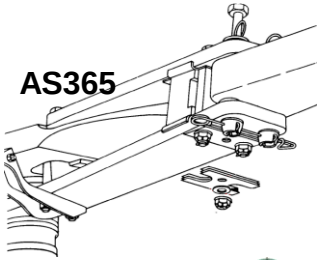
Three blade parameters to tune the rotor :

Mass in the sleeves

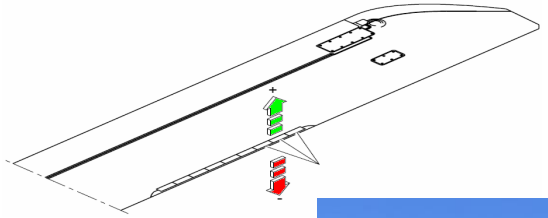
NH90 -TTH



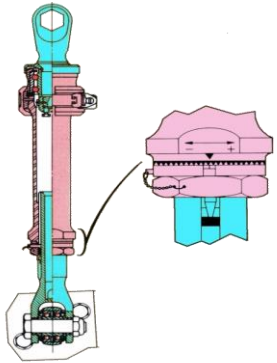
AS365



Tabs inclination



Length of the pitch rod



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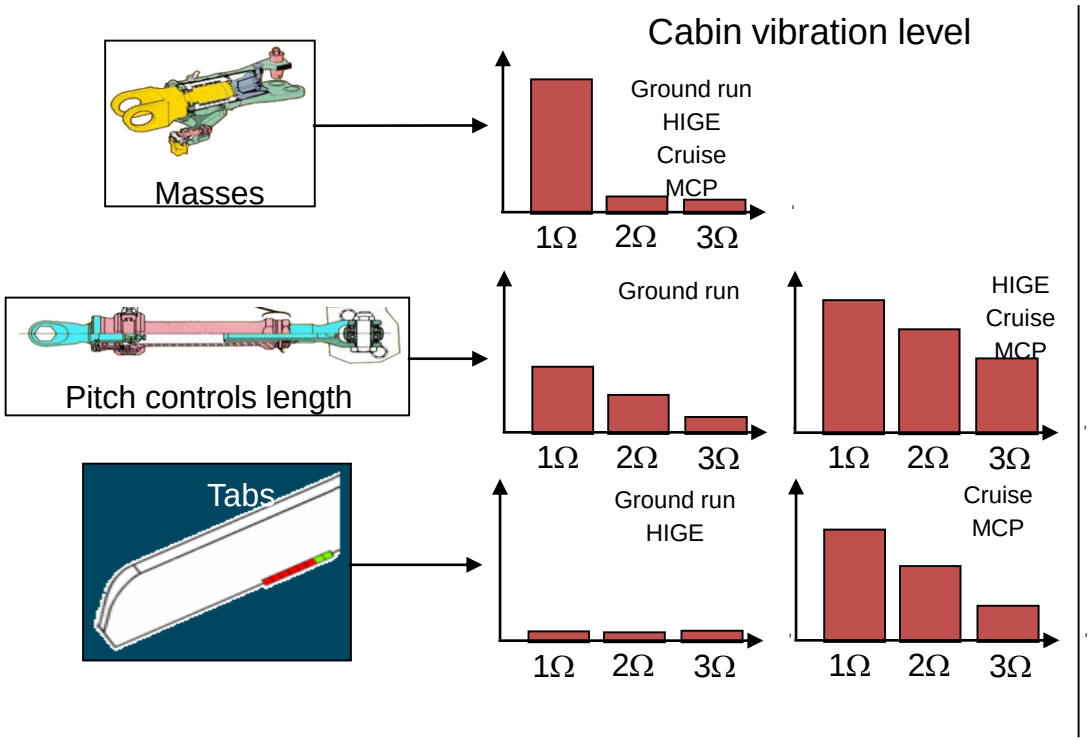
Rotor Track & Balance methods

Automatic method: Neural network



Tuning principle

- One shot tuning
  (1 acquisition flight + 1 Verfication flight)
- No track checking
  (optimisation for automatic track alignment)
- No specialist required
  (Easy interpretation)

Vibration acquisitions $\begin{bmatrix} \beta \end{bmatrix}$

↓

Minimization of the cost function

$$(\beta + H(\alpha))^T w(\beta + H(\alpha))$$

↓

Tuning parameters $\begin{bmatrix} \alpha \end{bmatrix}$

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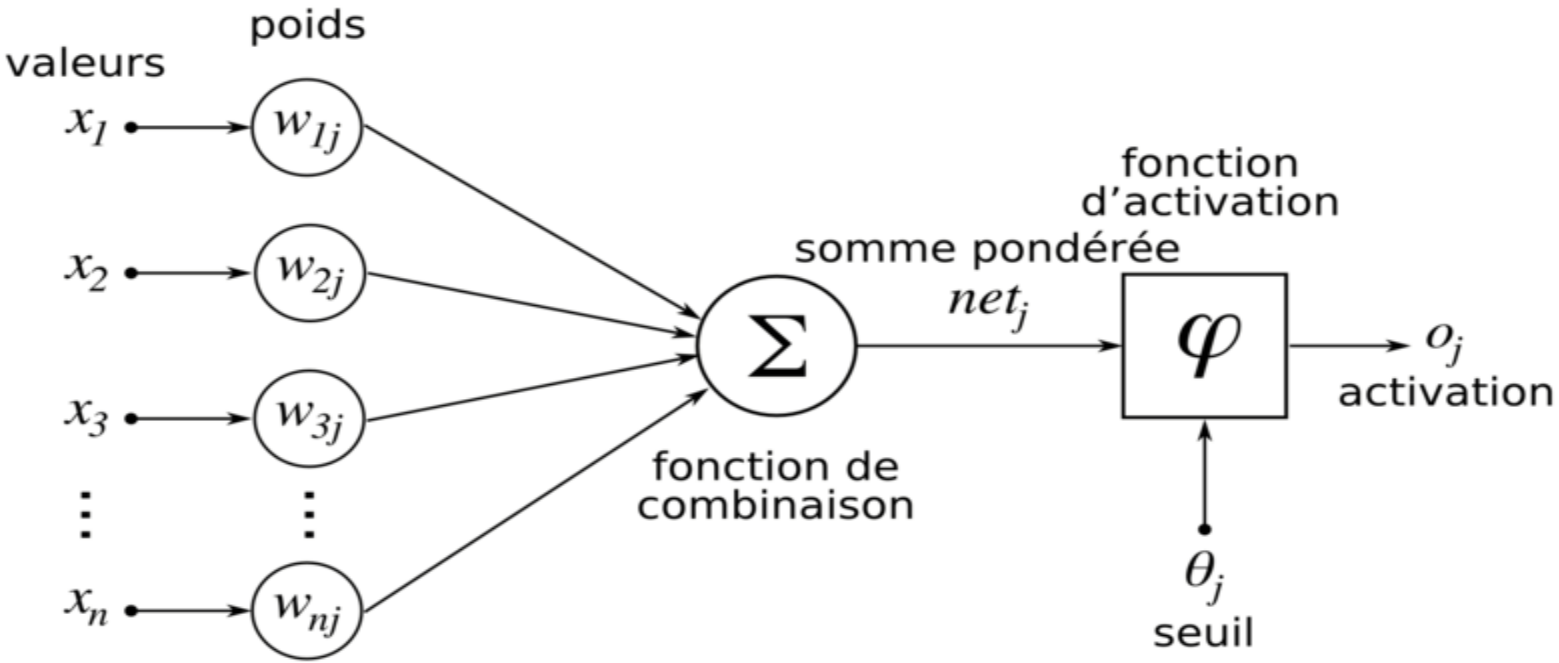
EXTRA 2: Neural network illustration



Helicopter / Pilot Interaction

Improve parameters **visualization**

Give **a better understanding** of the environnement

Alert of danger and flight **limitations**

Improve Pilot Cabin **Ergonomy**

Re-think all **interactions** between **pilot & systems**

Virtual Co-pilot **assistance**

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Lidar – how it works ?

PULSE

TRAVEL TIME * SPEED OF LIGHT

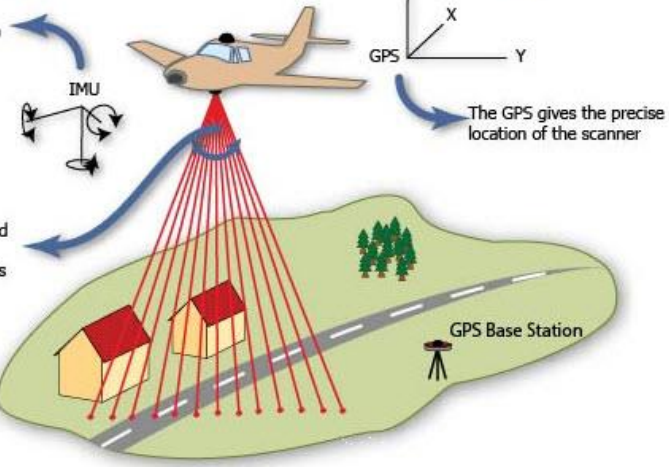
2

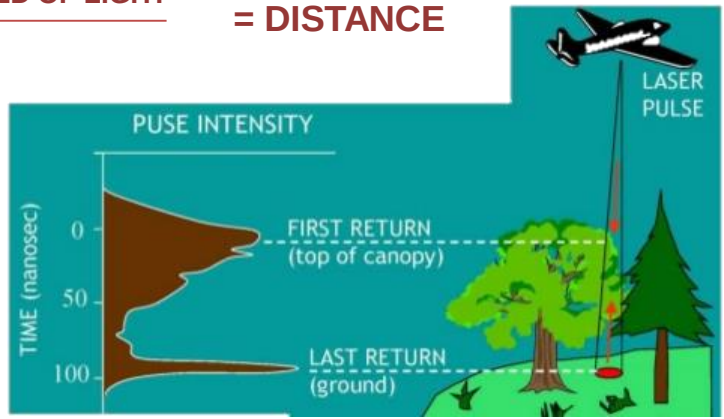
= DISTANCE

SYSTEM CALCULATE THE SPEED OF LIGHT

RETURN

The IMU (inertial measurement unit) gives the precise orientation of the scanner





The LiDAR instrument emits rapid laser signals, sometimes up to <u>150,000 pulses per second.</u>

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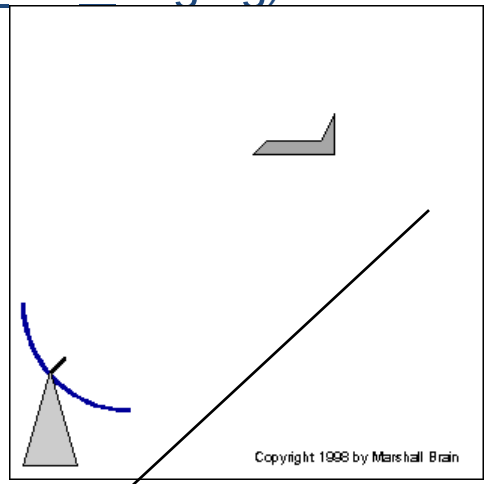
RADAR (Radio Detection And Ranging) - how it works ?

The radar set turns on its transmitter and shoots out a short, high-intensity burst of high-frequency radio waves.



The radar set then turns off its transmitter, turns on its receiver and listens for an echo.

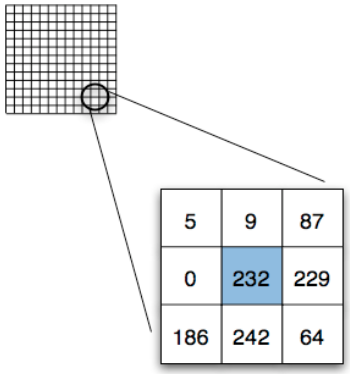
The radar set measures the time it takes for the echo to arrive, as well as the Doppler shift of the echo

Radio waves travel at the speed of light, roughly **1,000** feet per microsecond, so if the radar set has a good high-speed clock it can measure the distance of the airplane very accurately.

Using special signal processing equipment the radar set can also measure the Doppler shift very accurately and tell how fast the airplane is going.

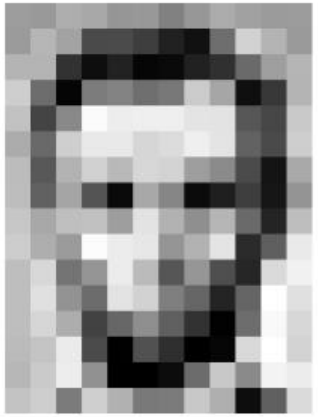
Computer Vision – how it works

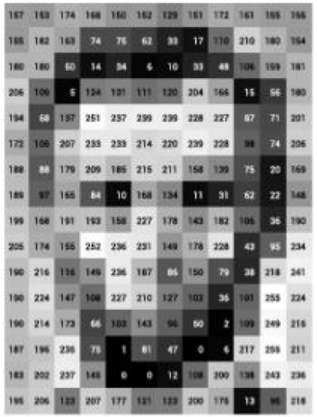
Each pixel in an image can be represented by a number, usually from 0 – 255.

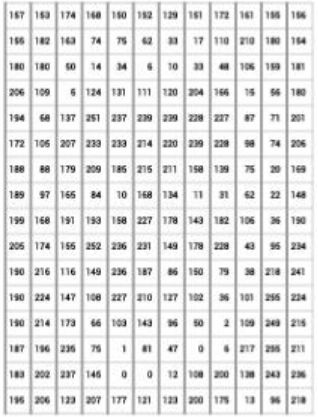


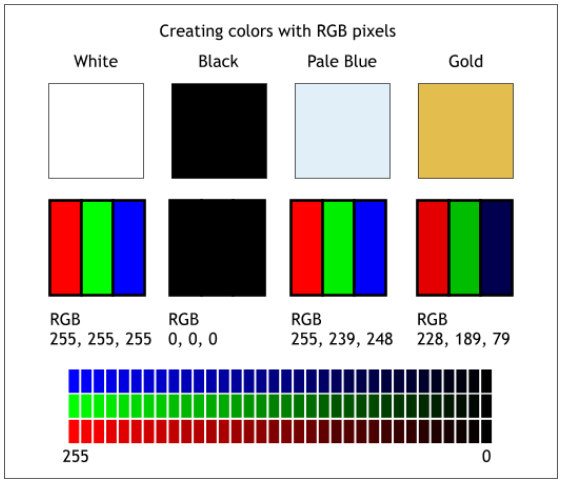
= (5 + 9 + 87 + 0 + 232 + 229 + 186 + 242 + 64) / 9

Computers usually read color as a series of 3 values – red, green, and blue (RGB) – on that same 0 – 255 scale. Now, each pixel actually has 3 values for the computer to store in addition to its position.









Machines interpret images very simply: as a series of pixels, each with their own set of color values.

Consider the simplified image below, and how grayscale values are converted into a simple array of numbers:

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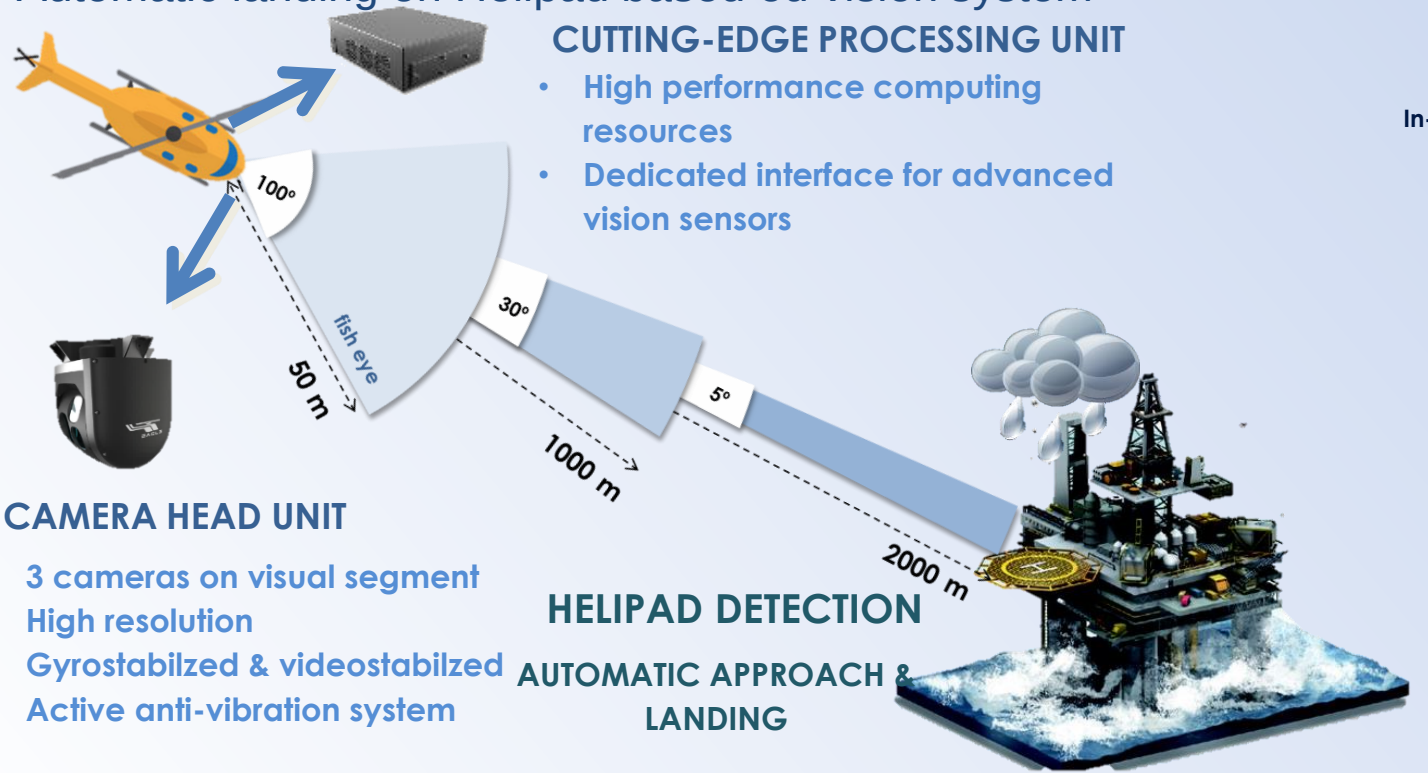
EAGLE

Automatic landing on Helipad based od vision system



CUTTING-EDGE PROCESSING UNIT

- High performance computing resources
- Dedicated interface for advanced vision sensors

CAMERA HEAD UNIT

- 3 cameras on visual segment
- High resolution
- Gyrostabilzed & videostabilzed
- Active anti-vibration system

HELIPAD DETECTION

AUTOMATIC APPROACH & LANDING

EAGLE

In-flight validation of the innovative on-board image processing system. Performed on an H225 flying tested

Demonstration with FCS coupled: Full Flight automation without pilot intervention: A significant step to autonomy.

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DIST 79.5 M
AZM 170.0 °
EL 33.5 °

Following the mustache

Conclusions et Questions