Systèmes multi-drones pour les applications maritimes

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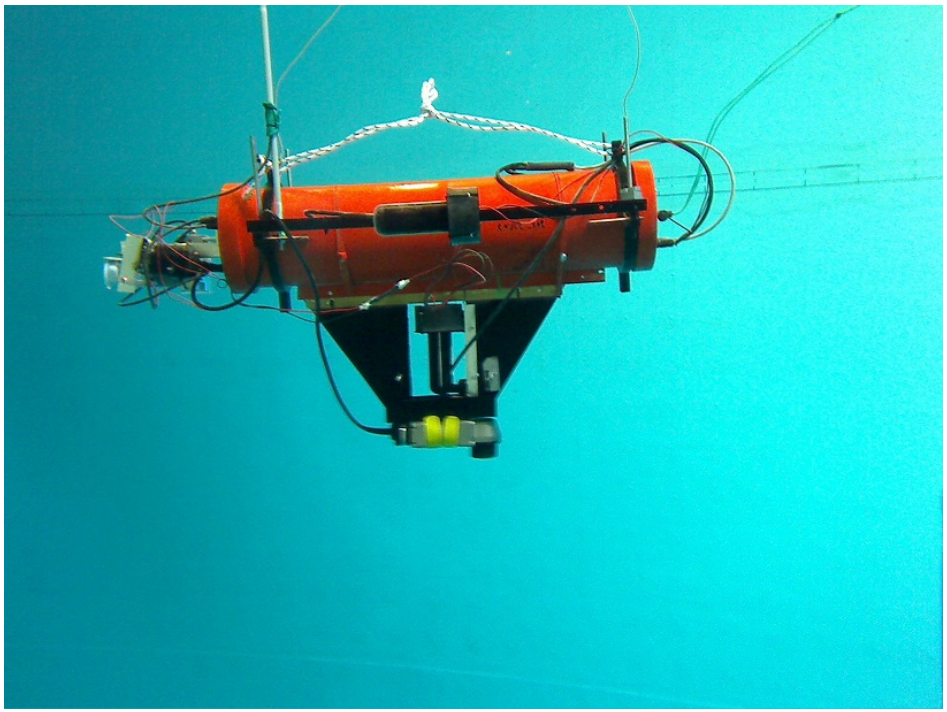
JSN, Ecole Navale, 2 février 2017

What is a robot ?

A robot is a mechanical system equipped with actuators, sensors and a brain.



Saucisse (ENSTA Bretagne). First at SAUCE'2016

Gouelack (ENSTA Bretagne)

Second at WRSC'2016

Premier catégorie lourde HYDROcontest 2016

Vaimos at the WRSC (ENSTA Bretagne-IFREMER)
with F. Le Bars, O. Ménage, P. Rousseau

Vaimos in Angers

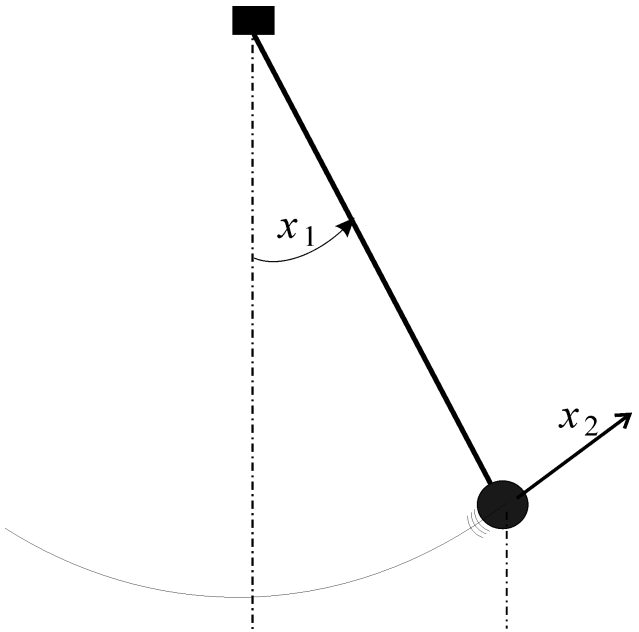
A robot is a dynamical system

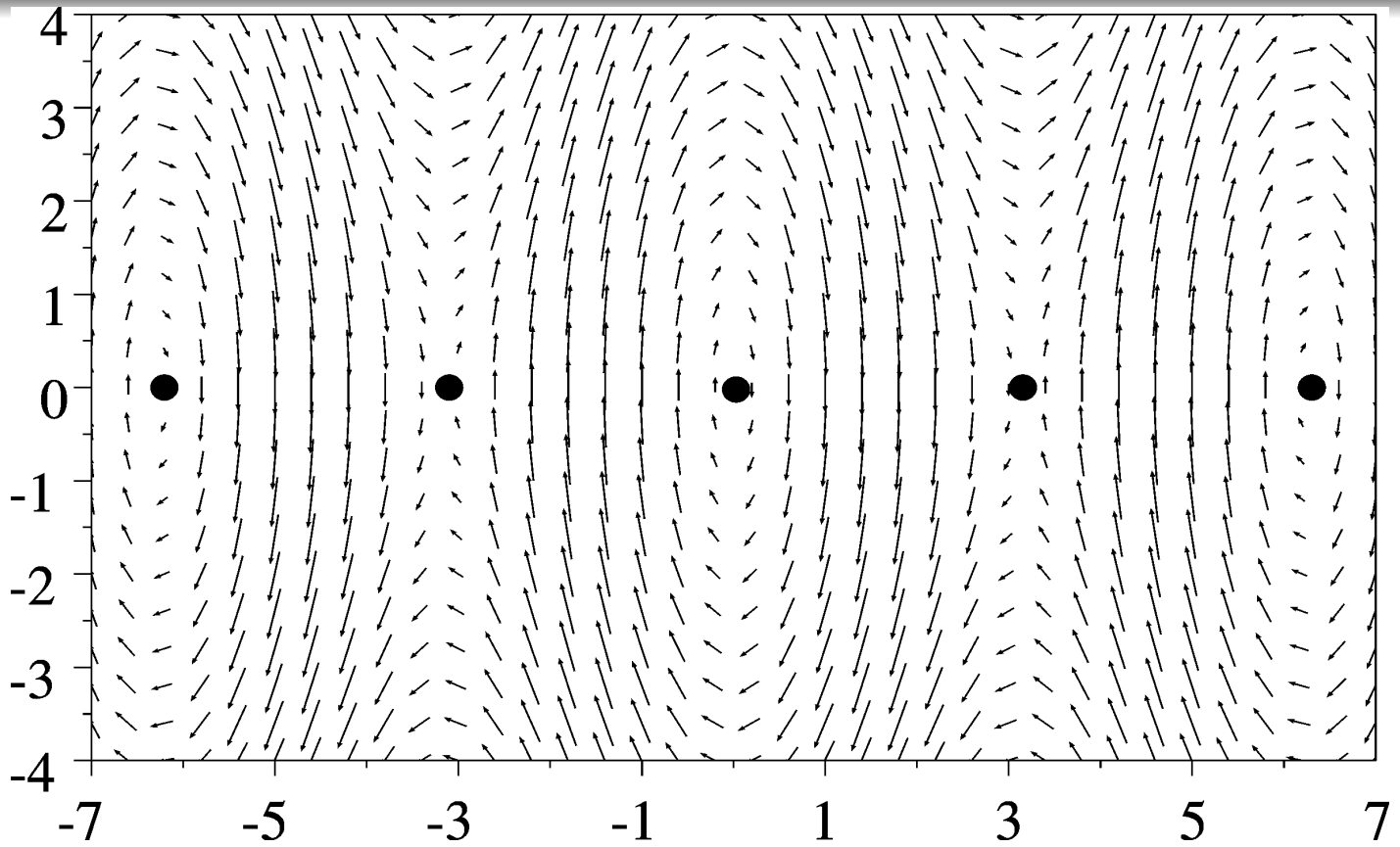
A dynamical system can be written as [Newton 1690]

$$\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x}).$$

Example: The pendulum

$$\begin{cases} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= -\sin x_1 . \end{cases}$$

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A robot is a vehicle

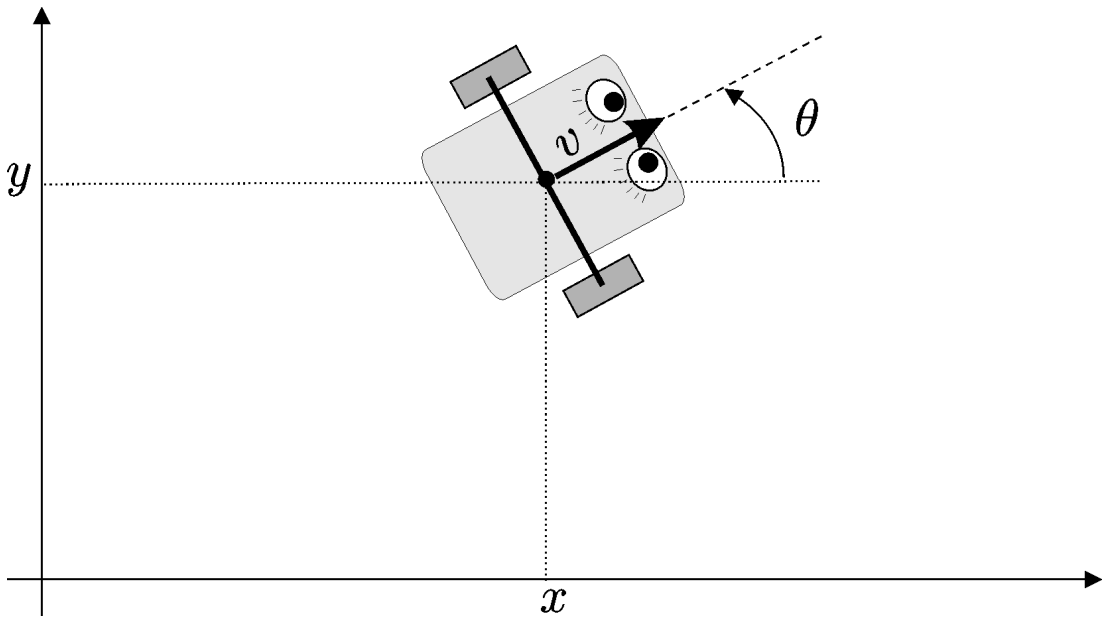
A **vehicle** is a controlled mechanical system

$$\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x}, \mathbf{u}).$$

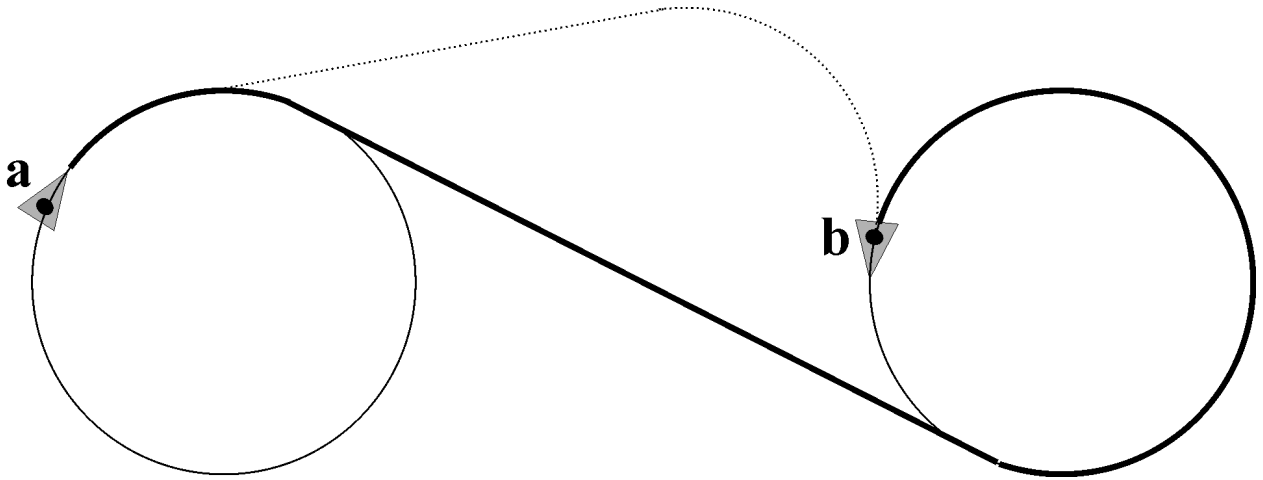
Example. Dubin's car (1957).

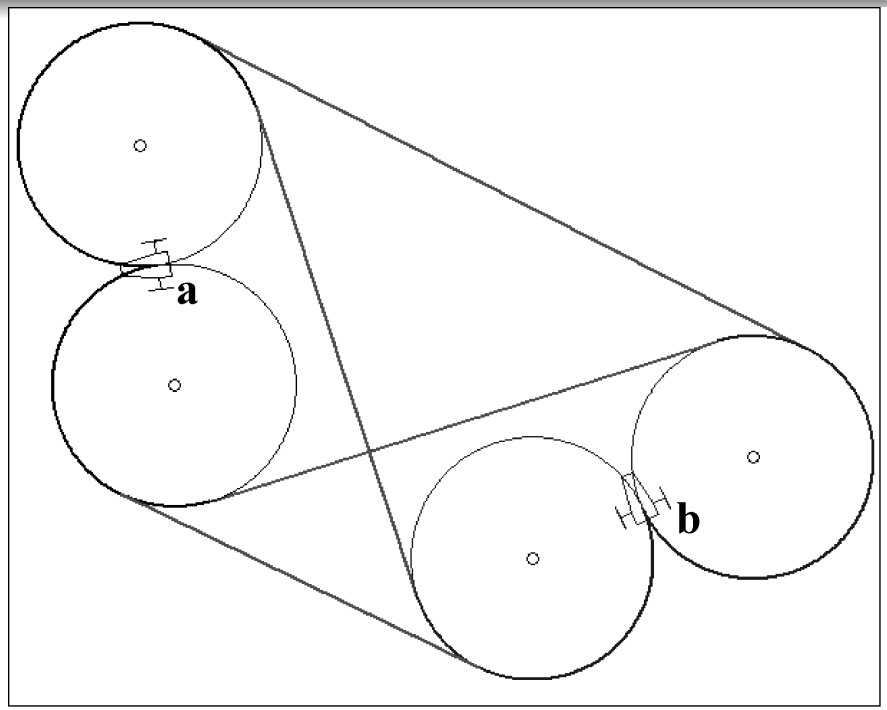
$$\begin{cases} \dot{x} &= \cos\theta \\ \dot{y} &= \sin\theta \\ \dot{\theta} &= u \end{cases}$$

with $u \in [-1, 1]$.



Dubin's paths

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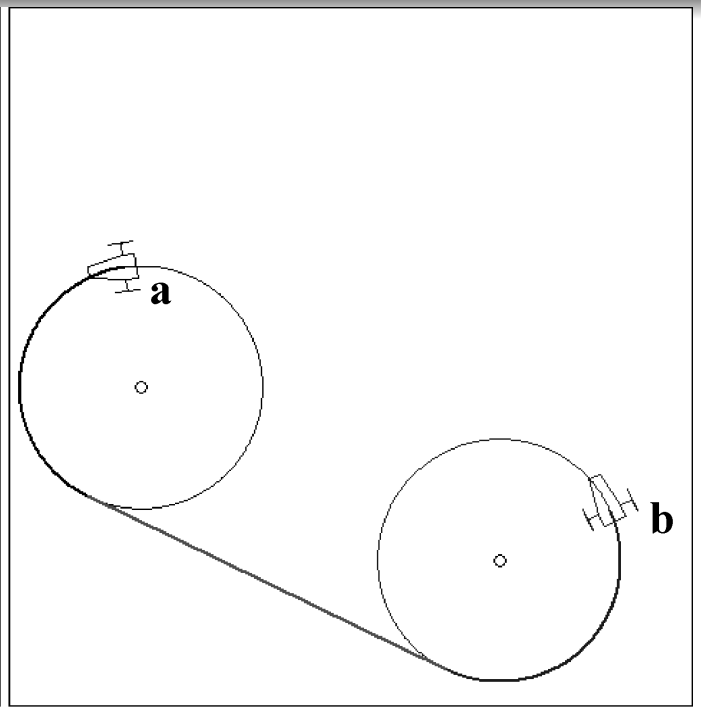

a
b

A robot is an intelligent vehicle

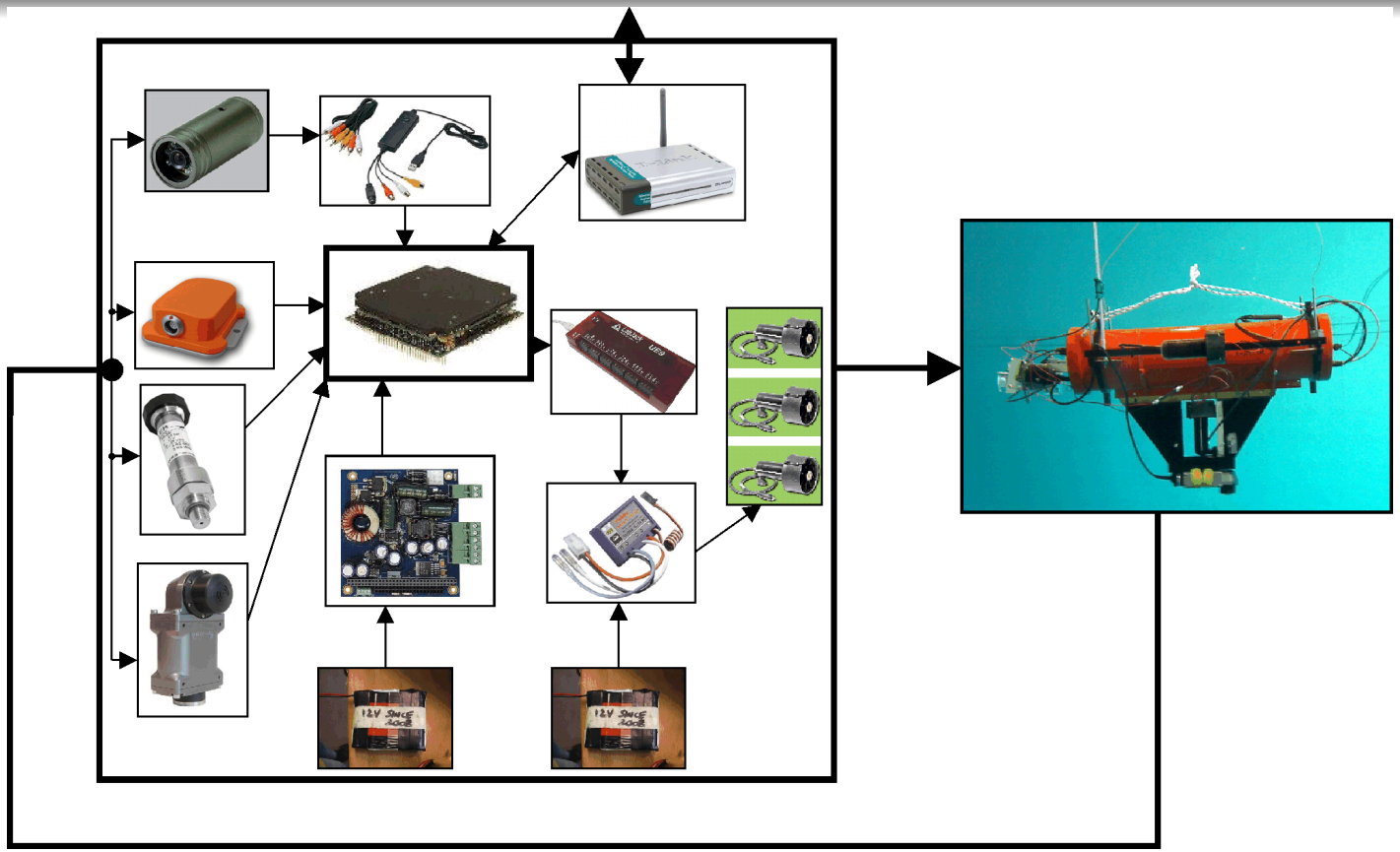
A robot is a vehicle with actuators, sensors, and a brain

$$\begin{array}{lcll} \dot{\mathbf{x}} & = & \mathbf{f}(\mathbf{x},\mathbf{u}) & \text{(évolution)} \\ \mathbf{y} & = & \mathbf{g}(\mathbf{x}) & \text{(observation)} \\ \mathbf{u} & = & \mathbf{h}(\mathbf{y}). & \text{(contrôle)} \end{array}$$

We have

$$\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x},\mathbf{h}(\mathbf{g}(\mathbf{x}))) = \psi(\mathbf{x})$$

and thus a robot is a dynamical system.



Why do we need robots ?

Brest-Douarnenez. January 17, 2012


minji
F78


Google Earth
Fichier Édition Affichage Outils Ajouter Aide
Brest
Plouzané
Plougastel-Daoulas
Le Conquet
Crozon
Douarnenez
Image © 2012 GeoEye
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2012 IGN-France
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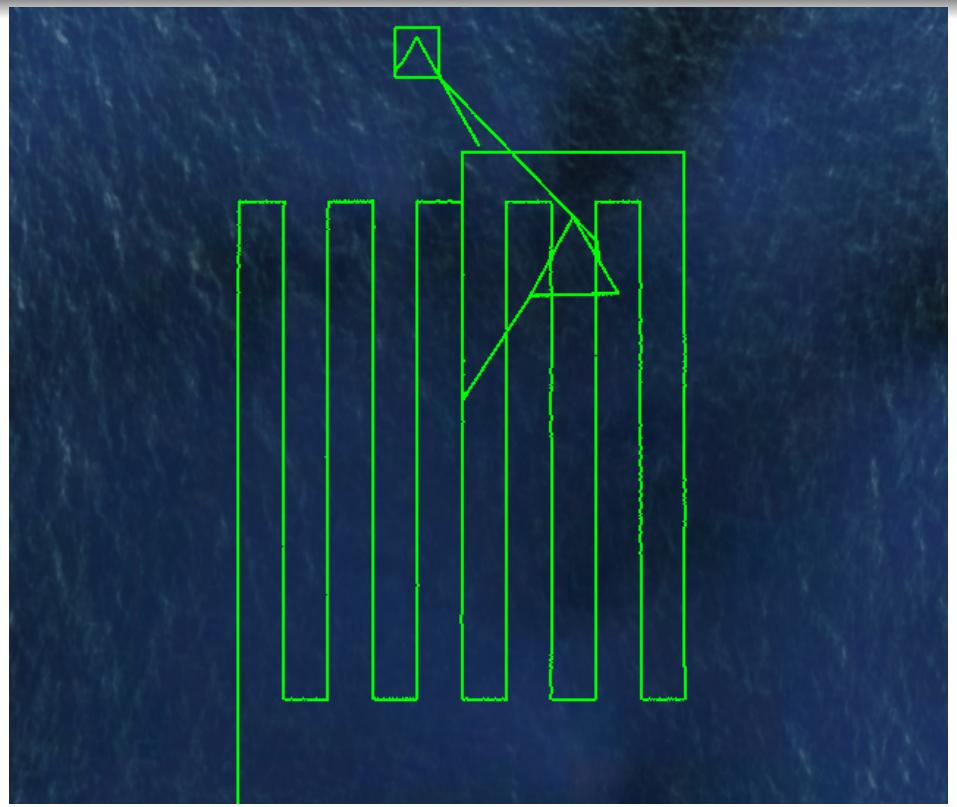
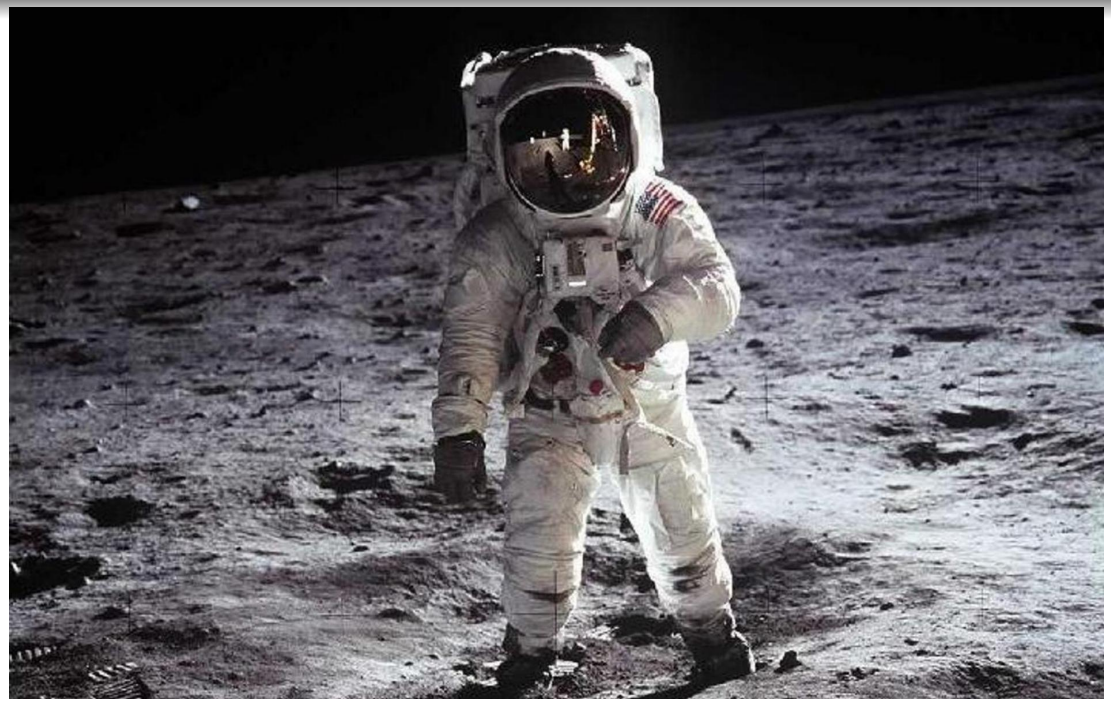
Altitude 53.47 km

Video: Vaimos dans l'océan Atlantique



Middle of Atlantique ocean, 350 km made by Vaimos, sept. 6-9, 2012.

Ocean satellites ?



Robots are needed for dirty, dangerous and dull jobs

Curiosity

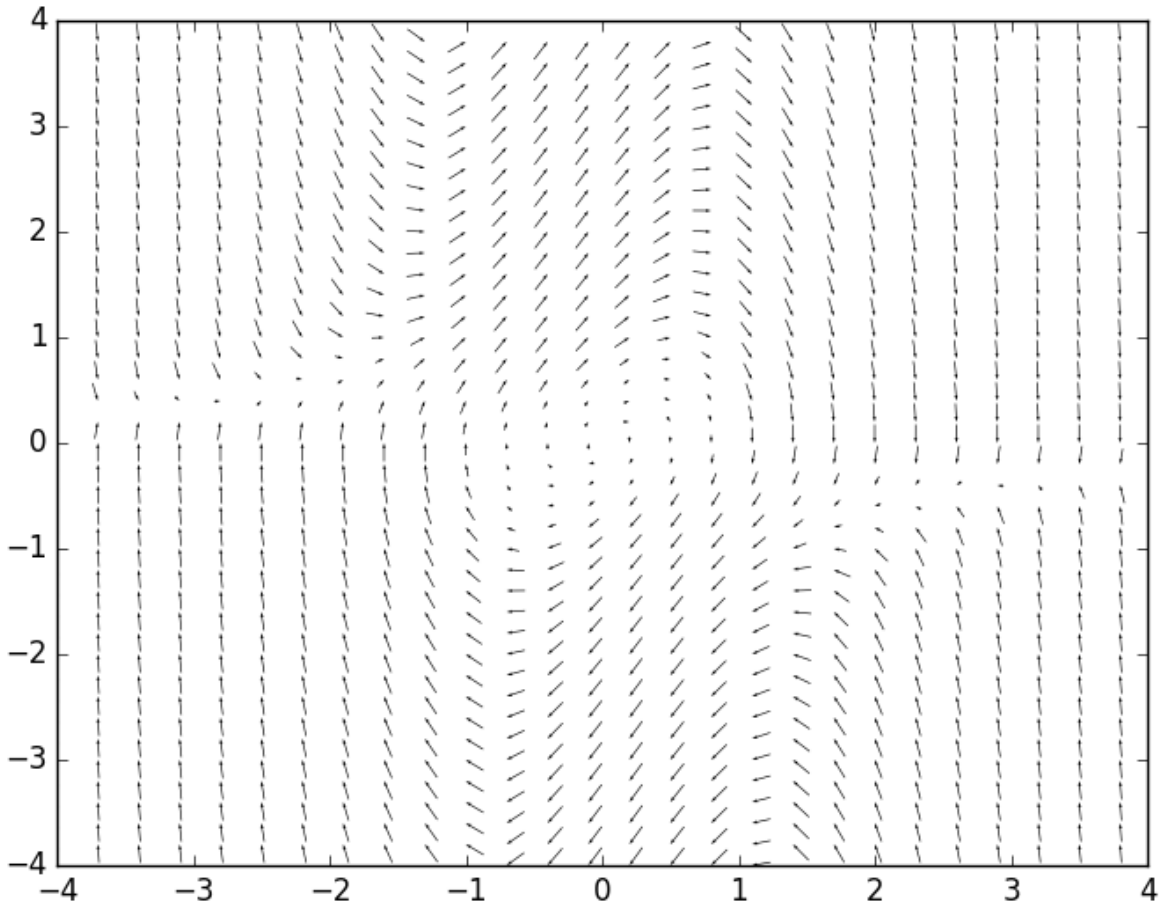
About 3,600 satellites in orbit (1,000 are operational).
In the ocean, we have gliders, drifting buoys.
In the ocean, a robot could be autonomous in energy, and could survive for years (persistent autonomy).

Security

A robot $\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x})$.

Example: The Van der Pol system

$$\begin{cases} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= \left(1 - x_1^2\right) \cdot x_2 - x_1 \end{cases}$$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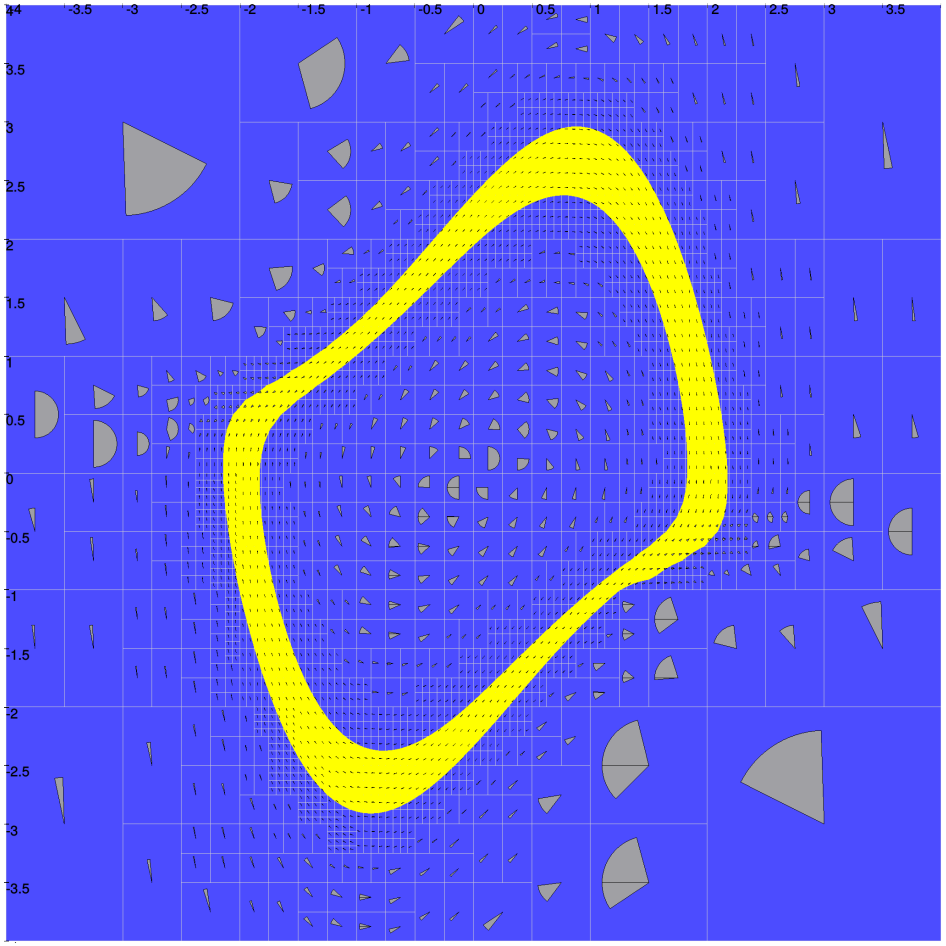
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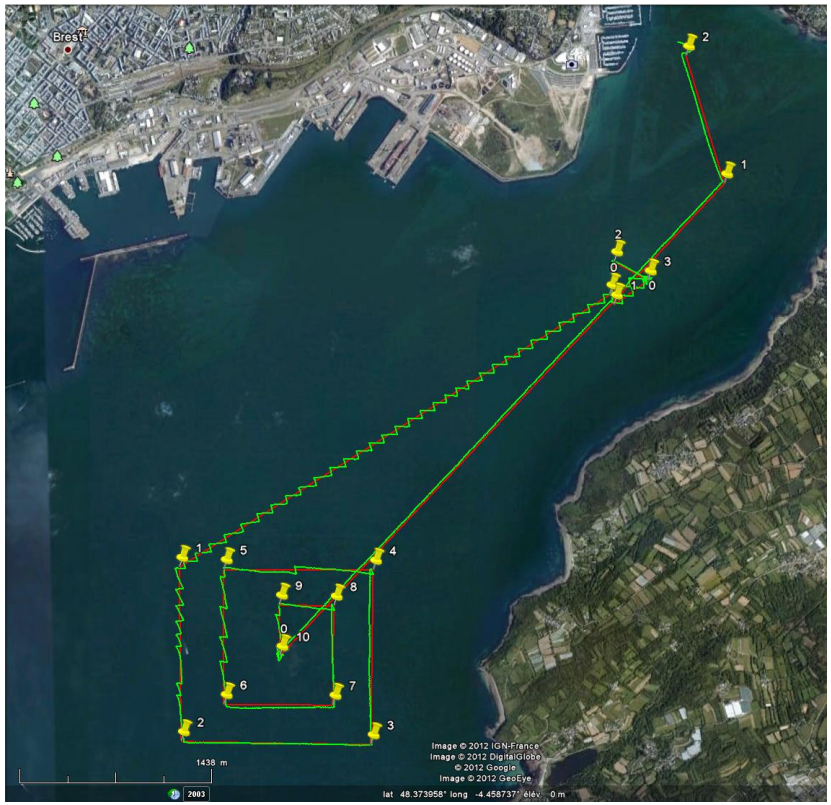
Brest
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1438 m
Image © 2012 IGN-France
Image © 2012 DigitalGlobe
© 2012 Google
Image © 2012 GeoEye

Video: Démonstration au forum DGA à l'X

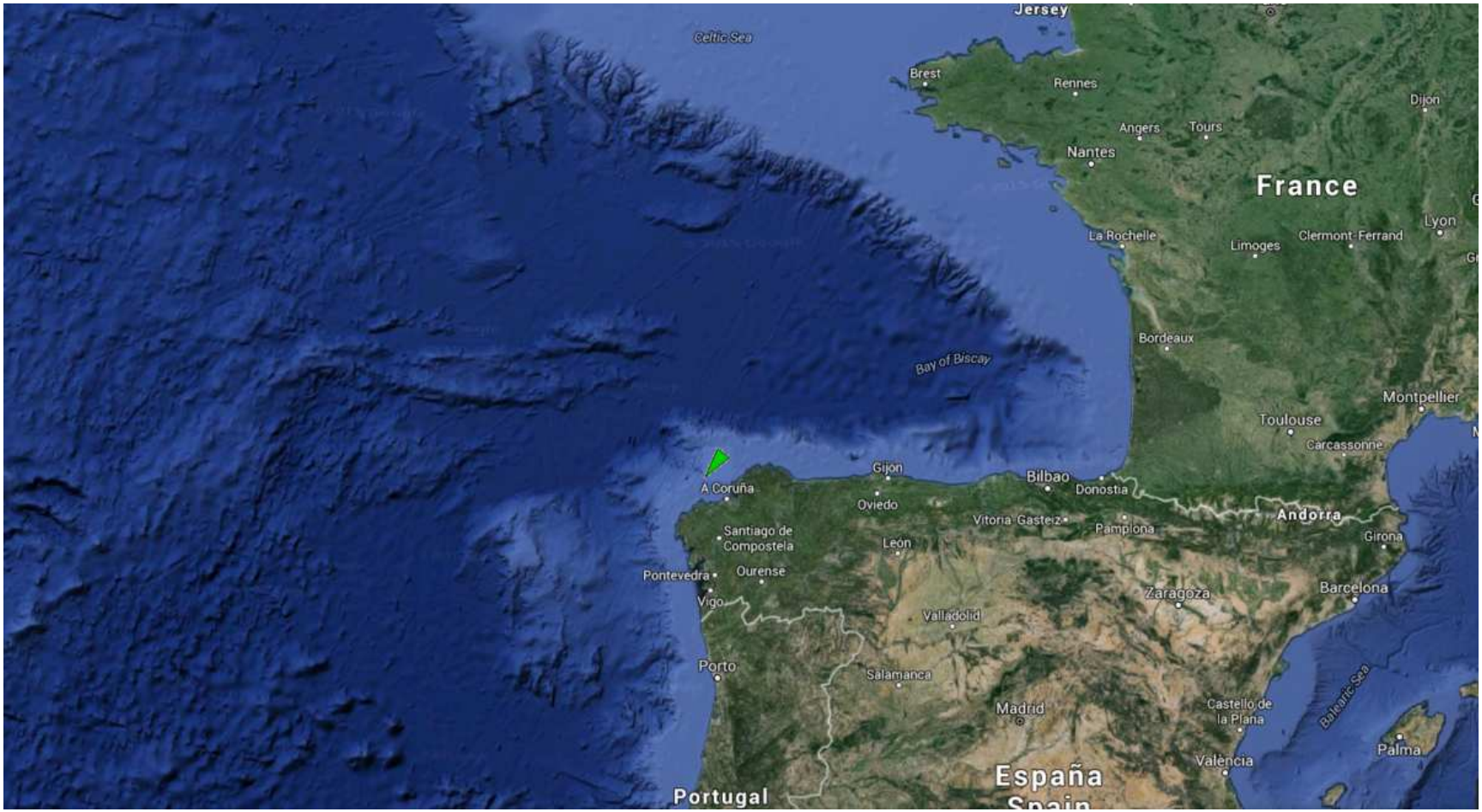
Groups for security

Video: Projet COMET

Secure a zone

INFO OBS. Un sous-marin nucléaire russe repéré dans le Golfe de Gascogne

Le navire a été repéré en janvier. Ce serait la première fois depuis la fin de la Guerre Froide qu'un tel sous-marin, doté de missiles nucléaires, se serait aventuré dans cette zone au large des côtes françaises.



Bay of Biscay 220 000 km^2

An intruder

- Several robots $\mathscr{R}_1, \ldots, \mathscr{R}_n$ at positions $\mathbf{a}_1, \ldots, \mathbf{a}_n$ are moving in the ocean.
- If the intruder is in the visibility zone of one robot, it is detected.

- We assume that a virtual intruder exists inside $\mathbb{G}$.
- We localize it with a set-membership observer inside $\mathbb{X}(t)$.
- The secure zone corresponds to the complementary of $\mathbb{X}(t)$.

Assumptions

- The intruder satisfies

$$\dot{\mathbf{x}} \in \mathbb{F}(\mathbf{x}(t)).$$

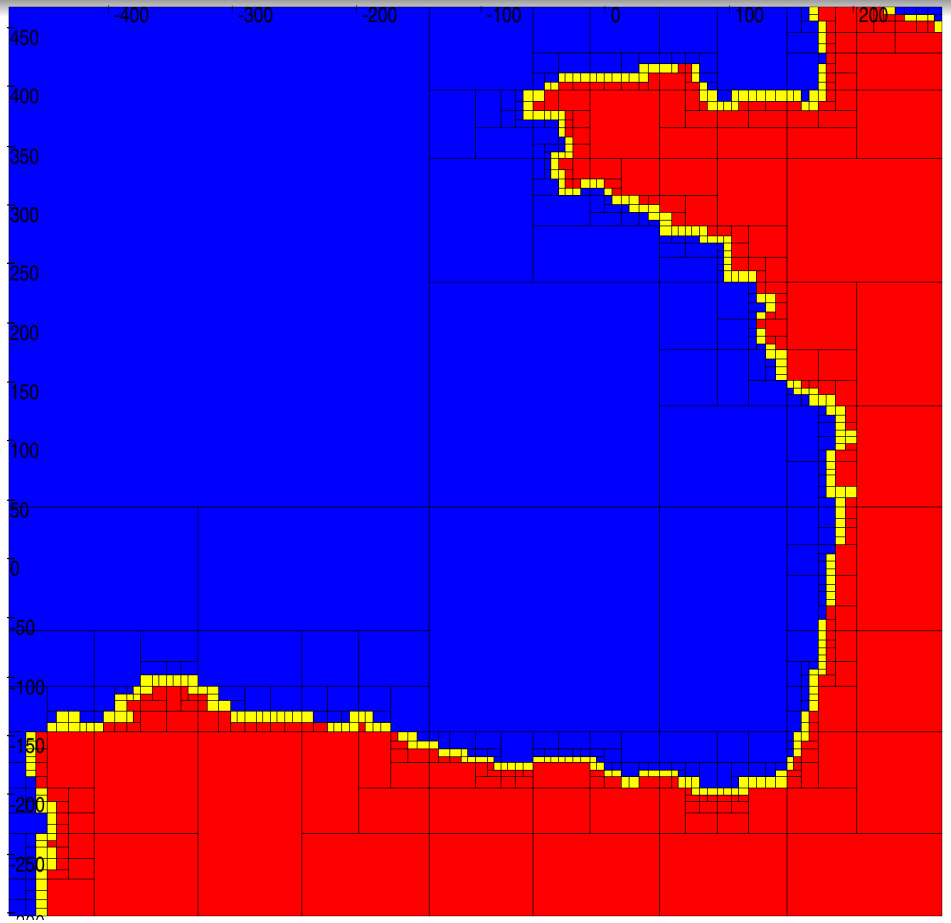
- Each robot $\mathscr{R}_i$ has the visibility zone $g_{\mathbf{a}_i}^{-1}([0, d_i])$ where d_i is the scope.

Theorem. An (undetected) intruder has a state vector $\mathbf{x}(t)$ inside the set

$$\mathbb{X}(t) = \mathbb{G} \cap (\mathbb{X}(t - dt) + dt \cdot \mathbb{F}(\mathbb{X}(t - dt)) \cap \bigcap_i g^{-1}_{\mathbf{a}_i(t)}([d_i(t), \infty]),$$

where $\mathbb{X}(0) = \mathbb{G}$.

Set $\mathbb{G}$ in white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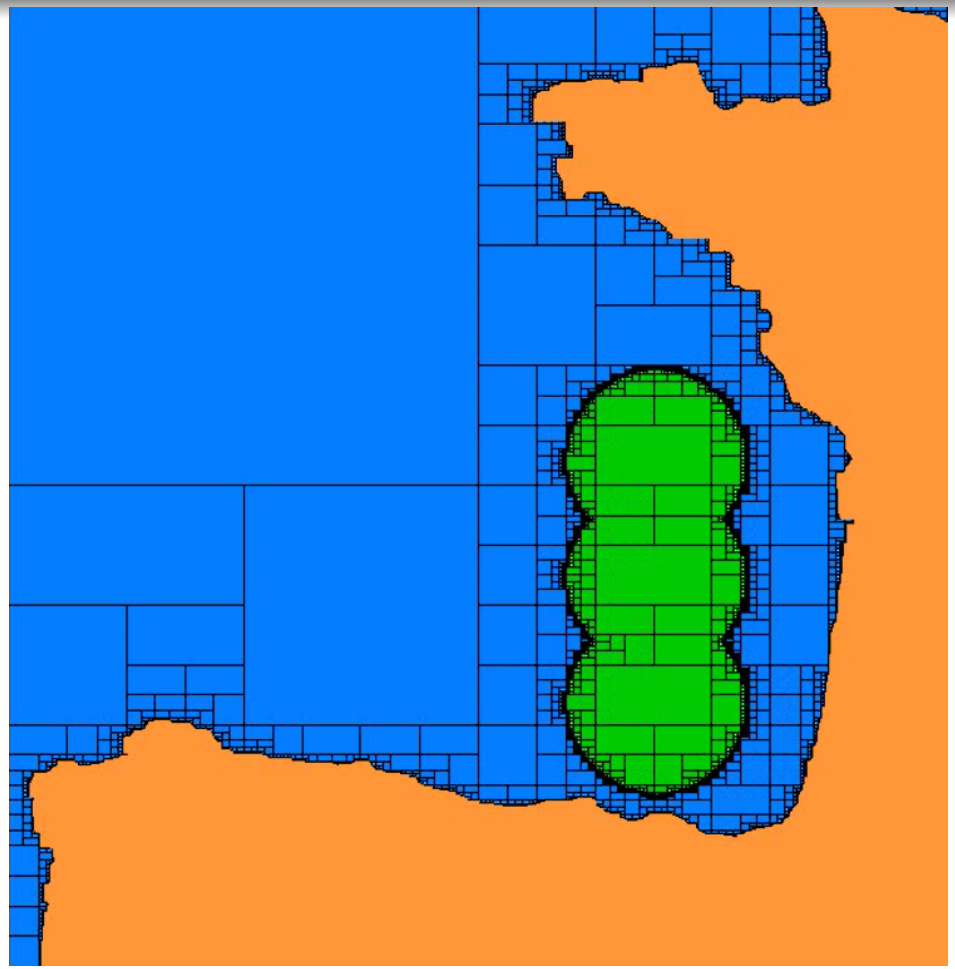
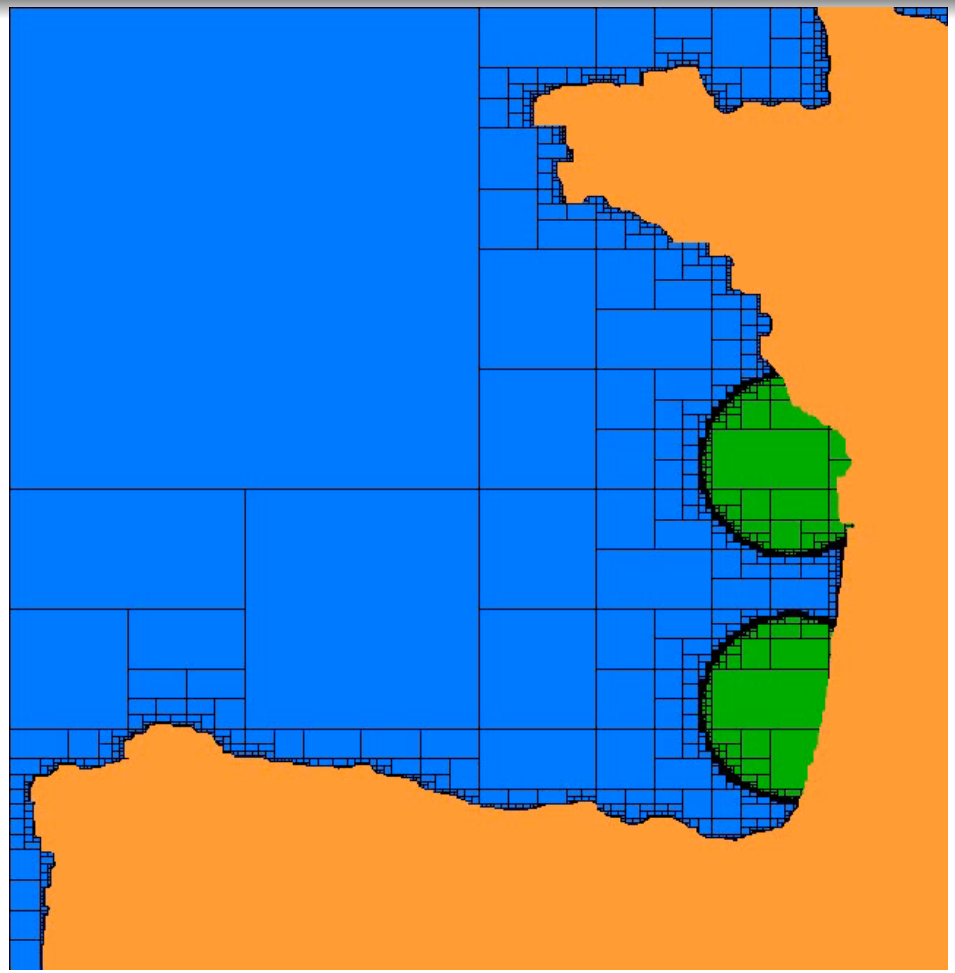
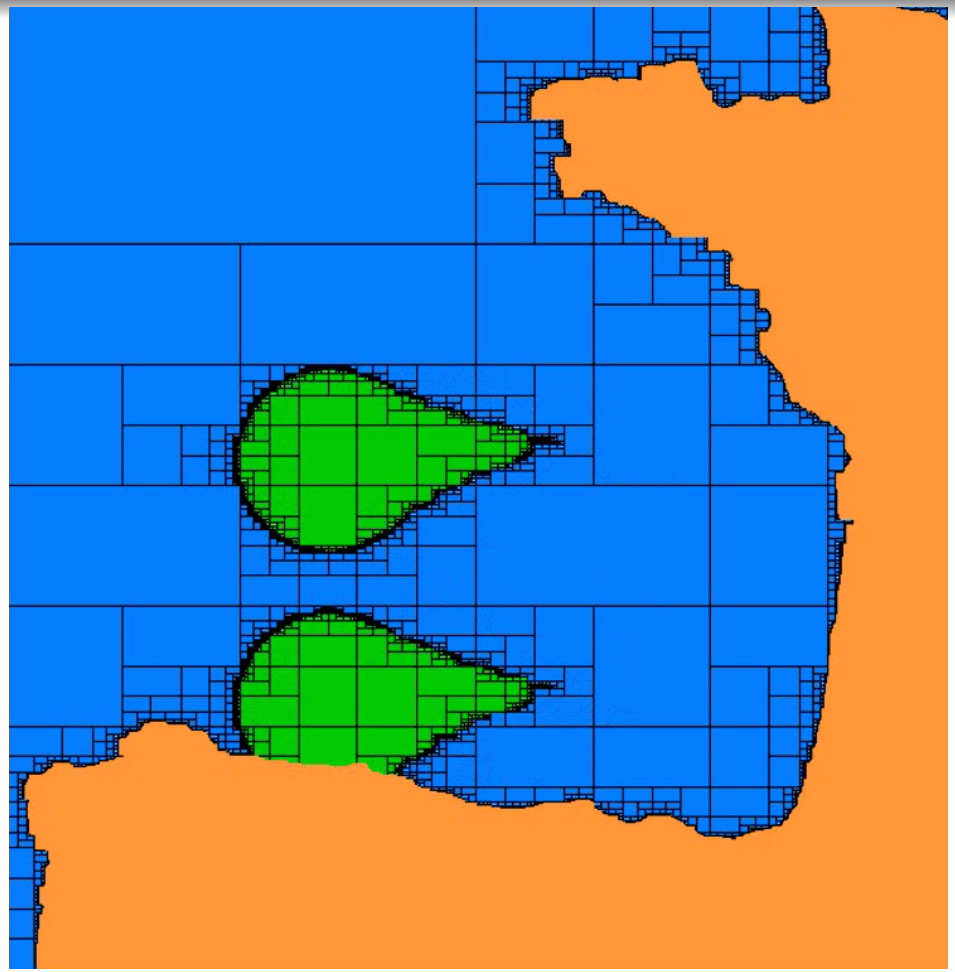


green: $\bigcup_i g^{-1}_{\mathbf{a}_i(t)}([0, d_i(t)])$

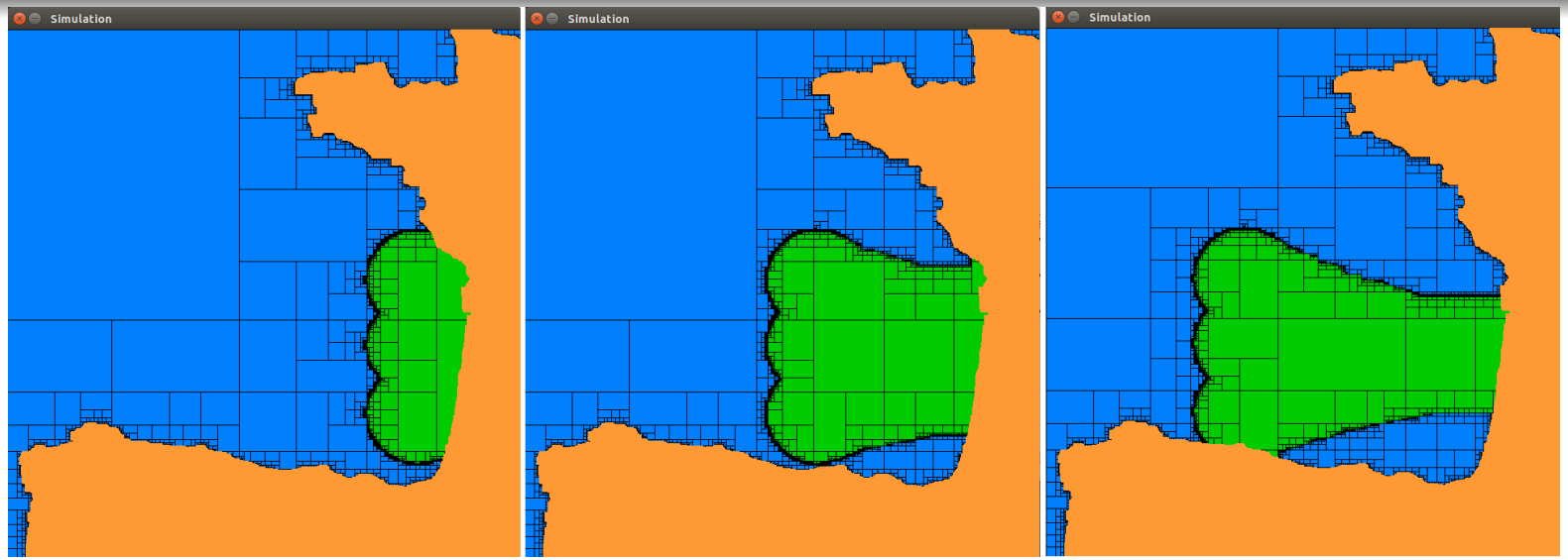


Blue: $\mathbb{G} \cap \bigcap_i g^{-1}_{\mathbf{a}_i(t)}([d_i(t), \infty])$



Blue:

$$\mathbb{X}(t) = \mathbb{G} \cap (\mathbb{X}(t - dt) + dt \cdot \mathbb{F}(\mathbb{X}(t - dt))) \cap \bigcap_i g^{-1}_{\mathbf{a}_i(t)}([d_i(t), \infty]).$$


Simulation
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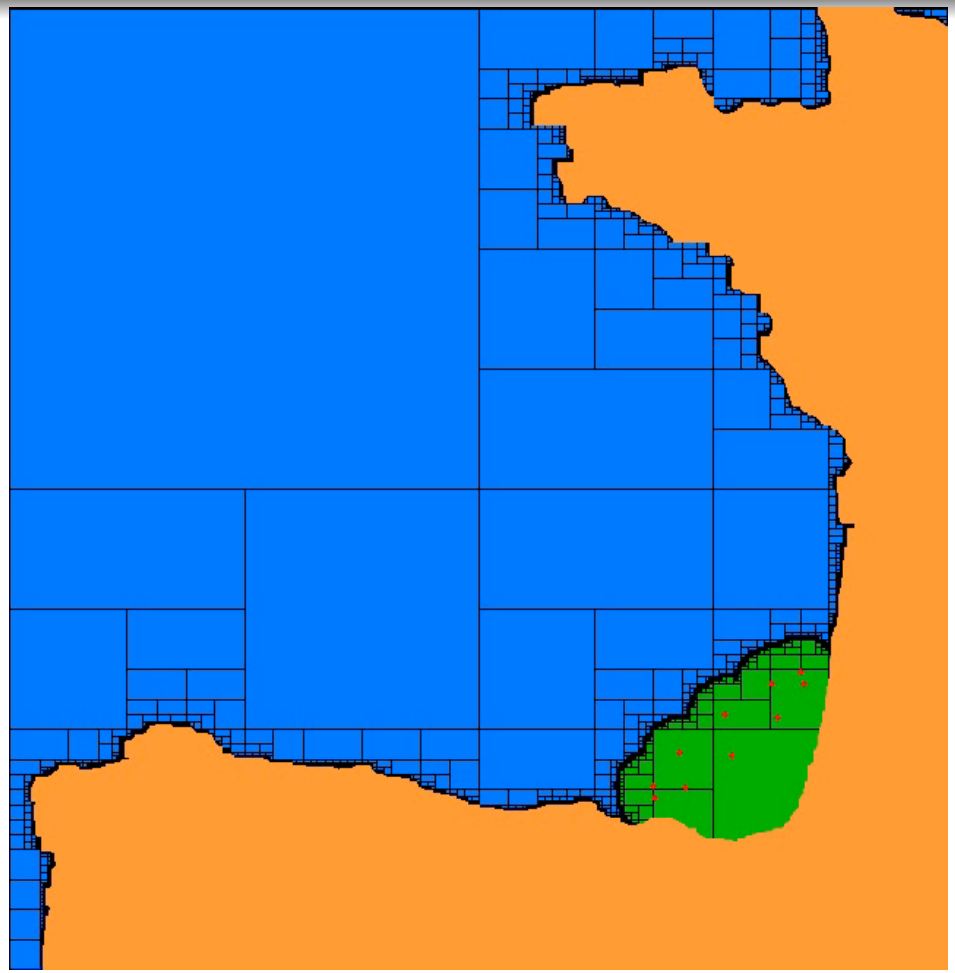

Video : https://youtu.be/rNcDW6npLfE

MOOCs and books


Rob
Mooc

Experiments


Argo


D36 918
HONDA
HONDA


ENSTA
caribe
ENSTA

Club and challenges

Vidéo: Club and challenges