Constraint Logic Programming for marine robotics

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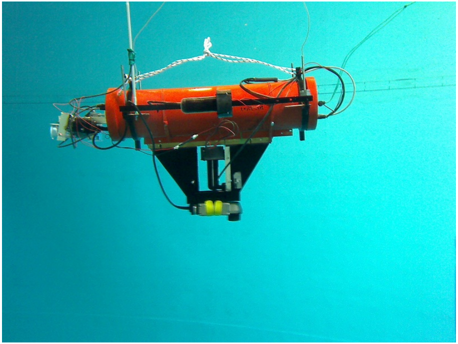
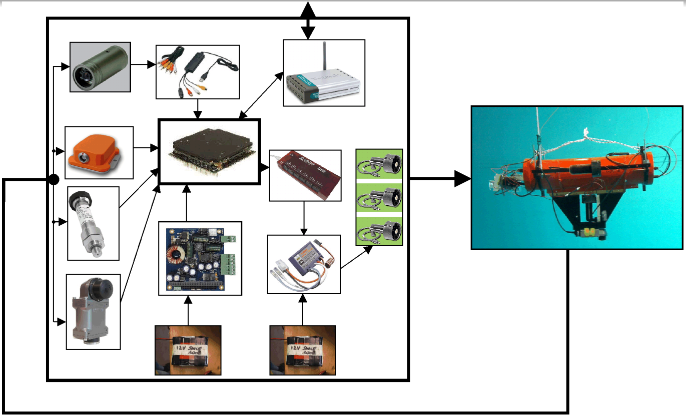
A robot

A robot is a mechanical system equipped with actuators, sensors and a brain.[1]



Saucisse (ENSTA Bretagne). First at SAUCE'2016



Prolog

```
frère(X,Y) :- parent(Z,X), parent(Z,Y), X ≠ Y
parent(X,Y) :- père(X,Y)
parent(X,Y) :- mère(X,Y)
mère(marie,jean)
père(jacques,jean)
père(jacques,pierre)
père(joseph,jacques)
?- frère(A,jean)
```

```
A(x,y) :- B(z,x), B(z,y), x ≠ y
B(x,y) :- C(x,y)
B(x,y) :- D(x,y)
D(4,1)
C(3,1)
C(3,2)
C(5,3)
?- A(a, 1)
```

Constraint logic programming

A(x,y) :- B(z,x), B(z,y), $x \neq y$
B(x,y) :- C(x,y)
B(x,y) :- D(x,y)
C(x,y):-x+y<3
D(x,y):-x^2+y^2=8
A(a, 1)

$$
\begin{array}{rcl}
A(x,y) & \Leftarrow & B(z,x) \wedge B(z,y) \wedge x \neq y \\
B(x,y) & \Leftarrow & C(x,y) \vee D(x,y) \\
C(x,y) & \Leftrightarrow & x+y<3 \\
D(x,y) & \Leftrightarrow & x^2+y^2=8 \\
A(a,1) & &
\end{array}
$$

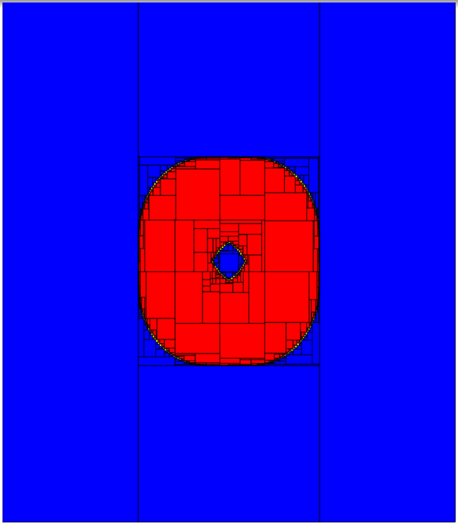
Localization

$$\begin{array}{rcl} f(\mathbf{x},\mathbf{a}) & = & (x_1-a_1)^2+(x_2-a_2)^2 \\ \mathscr{S}_1(\mathbf{x},\mathbf{a}) & \Leftrightarrow & f(\mathbf{x},\mathbf{a})\in[4,9] \\ \mathscr{S}(\mathbf{x}) & \Leftrightarrow & \mathbf{a}\in[-1,1]^2\wedge\mathscr{S}_1(\mathbf{x},\mathbf{a}) \end{array}$$

The solution set is

$$\mathbb{X}=\left\{\mathbf{x}\in\mathbb{R}^2\,|\,\exists\mathbf{a}\in[-1,1]^2,(x_1-a_1)^2+(x_2-a_2)^2\in[4,9]\right\}$$

```
from pyibex import *
from vibes import vibes
f = Function("x1","x2","a1","a2","(x1-a1)^2+(x2-a2)^2");
S1=SepFwdBwd(f,Interval(4,9))
A=IntervalVector([[-1,1],[-1,1]])
S2=SepProj(S1,A,0.001)
X0 =IntervalVector([[-10,10],[-10,10]]);
vibes.beginDrawing()
vibes.newFigure('Proj')
pySIVIA(X0,S2,0.1)
```



Variables may be trajectories

tubex-lib
1.0

Search docs

The following is an extract from the paper Guaranteed computation of robot trajectories.

Definition

A tube $[\mathbf{x}](\cdot)$ is defined as an envelope enclosing an uncertain trajectory $\mathbf{x}(\cdot):\mathbb{R}\rightarrow\mathbb{R}^n$. It is built as an interval of two functions $[\mathbf{x}^-(\cdot),\mathbf{x}^+(\cdot)]$ such that $\forall t,\ \mathbf{x}^-(t)\leqslant\mathbf{x}^+(t)$. A trajectory $\mathbf{x}(\cdot)$ belongs to the tube $[\mathbf{x}](\cdot)$ if $\forall t,\ \mathbf{x}(t)\in[\mathbf{x}](t)$. Fig. 1 illustrates a tube implemented with a set of boxes. This sliced implementation is detailed hereinafter.

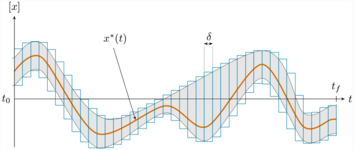


Fig. 1 A tube $[x](\cdot)$ represented by a set of slices. This representation can be used to enclose signals such as $x^*(\cdot)$.

Code example:

```
float timestep = 0.1;
Interval domain(0,10);
Tube x(domain, timestep, Function("t", "(t-5)^2 + [-0.5,0.5]"));
```

http://www.simon-rohou.fr/research/tubex-lib/ [2]

Saiboat robots

Vaimos (IFREMER and ENSTA) in Angers

youtu.be/tmfkKNM76Qg

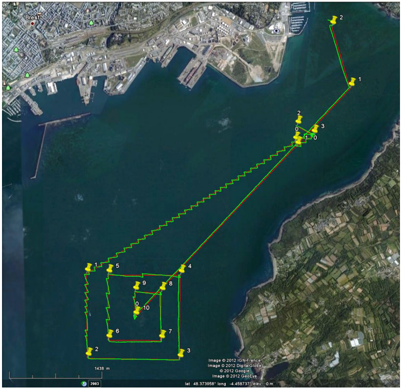

Brest
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Image © 2012 IGN-France
Image © 2012 DigitalGlobe
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Image © 2012 GeoEye
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lat 48.373958° long -4.458737° élév 0 m

youtu.be/DFg3K09cMwU

END

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Guaranteed Computation of Robots Trajectories.
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