Explorer et revenir pour un robot sous marin avec un échosondeur pour unique capteur extéroceptif

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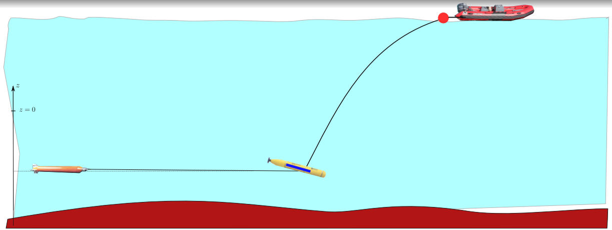
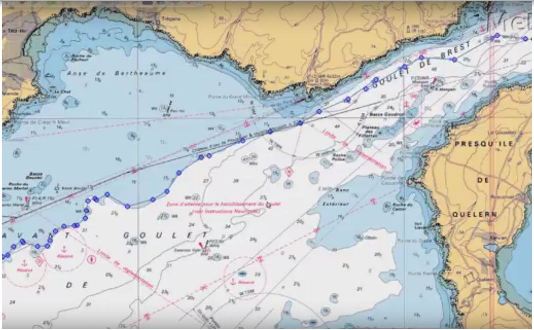
MOQESM 2018, Brest, SeaTechWeek
8-9-10 octobre 2018

La Cordelière and the Regent


z
z = 0



Tests du 7 juillet

youtu.be/cxVs1fDdm1s

Follow an isobath

Ile des morts experiment


Saint-Renan
Guilers
Bohars
Lambézellec
Le Relecq-Kerhuon
La Forest-Landerneau
Ploumoguer
Saint-Marc
Brest
Saint-Pierre
Plouzané
Locmaria-Plouzané
Dirinon
Saint-Urbain
Plougastel-Daoulas
Loperhet
Irvillac
Daoulas
Plougonvelin
Hôpital-Camfrout
Logonna-Daoulas
Roscanvel
Lanvéoc
Landévennec
Camaret-sur-Mer
Rosnoën
Crozon
Argol
Telgruc-sur-Mer
Saint-Nic
Plomodiern
E50
N165
E60


Île des Morts
ROSCANVEL
Camping Municipal
Route de la Fraternité
Route de Quélern
D355
Celtic Sea
Persuel
Le Disloup
Route du Milieu
Route du Ménez
Route de Keruzou
Rostellec
Taladec'h


1
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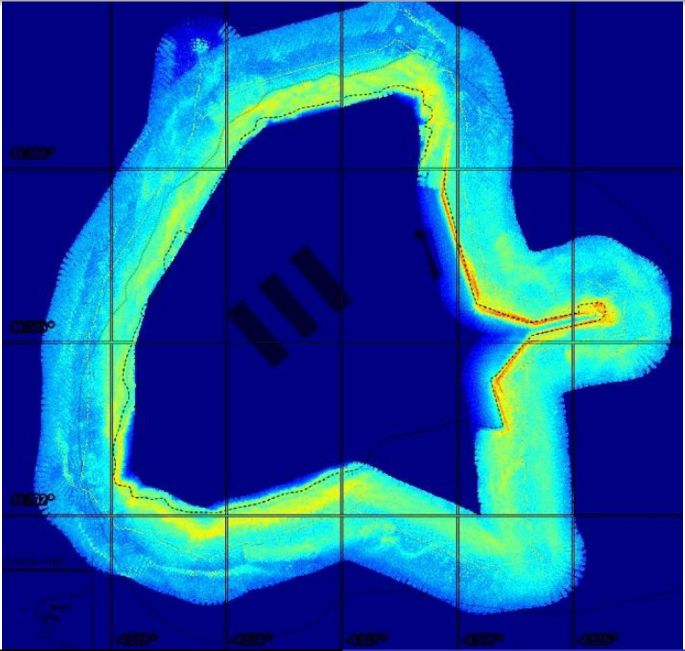
50m

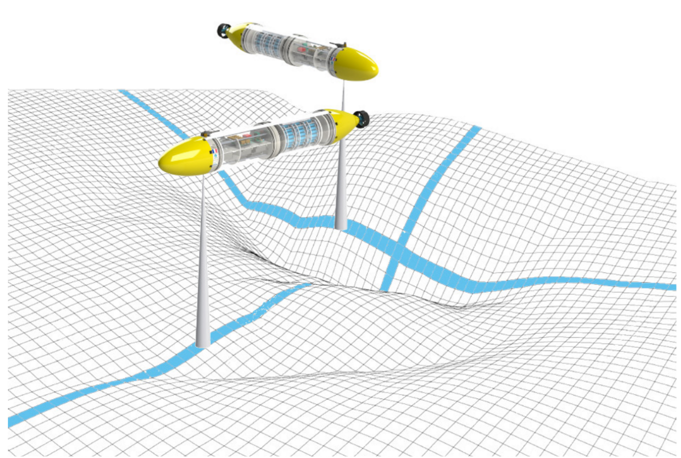


24 juillet 2013

Objective: Follow an isobath with an altimeter, a barometer and a low cost gyroscope.

Exploration

- SLAM paradigm
- Bridge-river paradigm



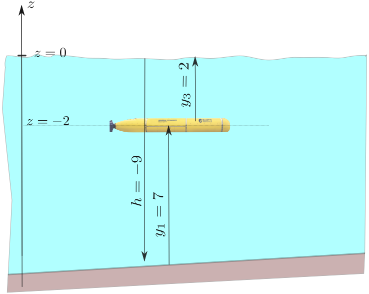
[3]

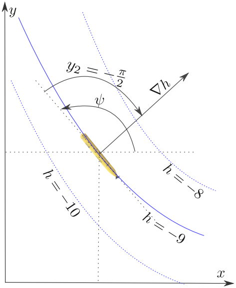
Consider an underwater robot:

$$\begin{cases} \dot{x} & = & \cos\psi \\ \dot{y} & = & \sin\psi \\ \dot{z} & = & u_1 \\ \dot{\psi} & = & u_2 \end{cases}$$

The observation function is

$$\begin{cases} y_1 = z - h(x,y) \\ y_2 = angle(\nabla h(x,y)) - \psi \\ y_3 = -z \end{cases}$$



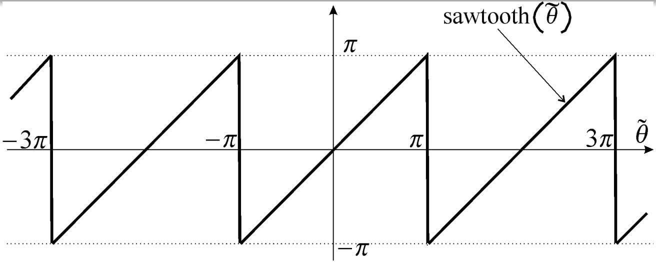


For the control of the depth:

$$u_1 = y_3 - \overline{y}_3$$

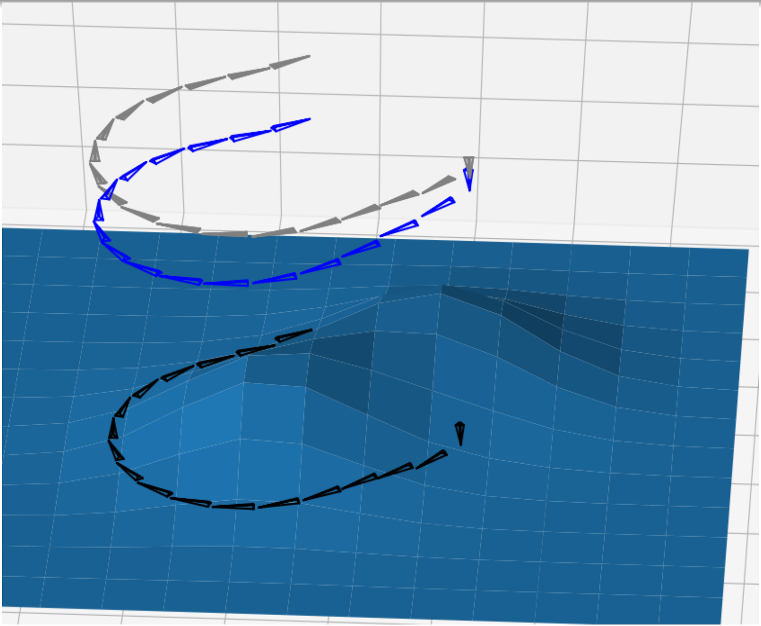
For the heading, we take [1]:

$$\begin{aligned} u_2 &= \tanh(e_2) + \text{sawtooth}(e_1) \\ &= -\tanh(h_0 + y_3 + y_1) + \text{sawtooth}(y_2 + \tfrac{\pi}{2}) \end{aligned}$$


sawtooth($\tilde{\theta}$)
π
-3π
$-\pi$
π
3π
$\tilde{\theta}$
$-\pi$

The controller is

$$\mathbf{u} = \begin{pmatrix} y_3 - \bar{y}_3 \\ -\tanh(h_0 + y_3 + y_1) + \text{sawtooth}(y_2 + \frac{\pi}{2}) \end{pmatrix}$$



The output $y_2 = angle(\nabla h(x,y)) - \psi$ should thus be estimated [2].
In the robot frame the underneath plane satisfies

$$z_1 = p_1 x_1 + p_2 y_1 + p_3$$

Prediction. We assume the seafloor locally planar. Thus:

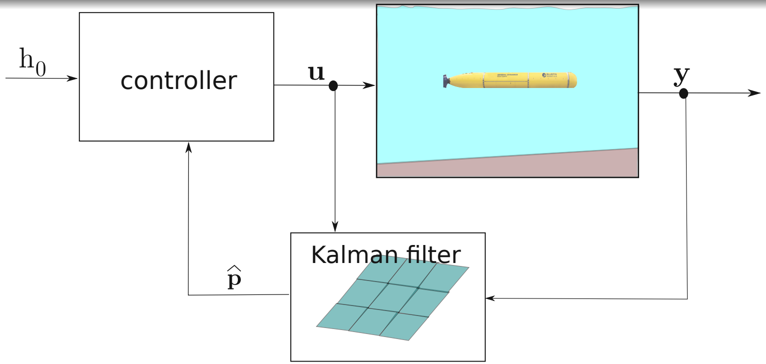
$$\dot{\mathbf{p}} = \begin{pmatrix} 0 & \dot{\psi} & 0 \\ -\dot{\psi} & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \mathbf{p}.$$

The prediction for the underneath plane is

$$\mathbf{p}(k+1) = \begin{pmatrix} 1 & dt \cdot u_2(k) & 0 \\ -dt \cdot u_2(k) & 1 & 0 \\ dt & 0 & 1 \end{pmatrix} \mathbf{p}(k) + \alpha(k).$$

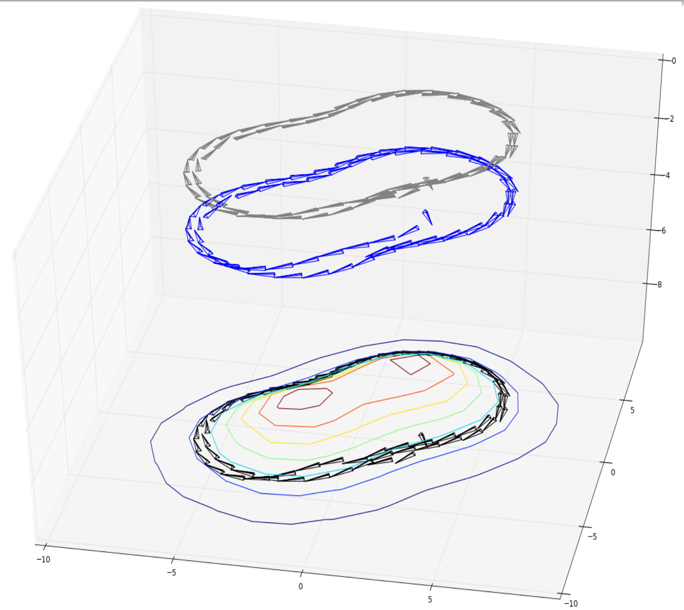
Correction.

$$-y_1 - y_3 = \begin{pmatrix} 0 & 0 & 1 \end{pmatrix} \mathbf{p}(k) + \beta(k).$$


h_0
controller
$\mathbf{u}$
$\mathbf{y}$
Kalman filter
$\widehat{\mathbf{p}}$

The controller is thus

$$\mathbf{u}=\begin{pmatrix} y_3-\bar{y}_3 \\ -\tanh(h_0-\hat{p}_3)+\text{sawtooth}(\text{atan2}(\hat{p}_2,\hat{p}_1)+\frac{\pi}{2}) \end{pmatrix}.$$


0
2
4
6
8
−10
−5
0
5
−10
−5
0
5

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