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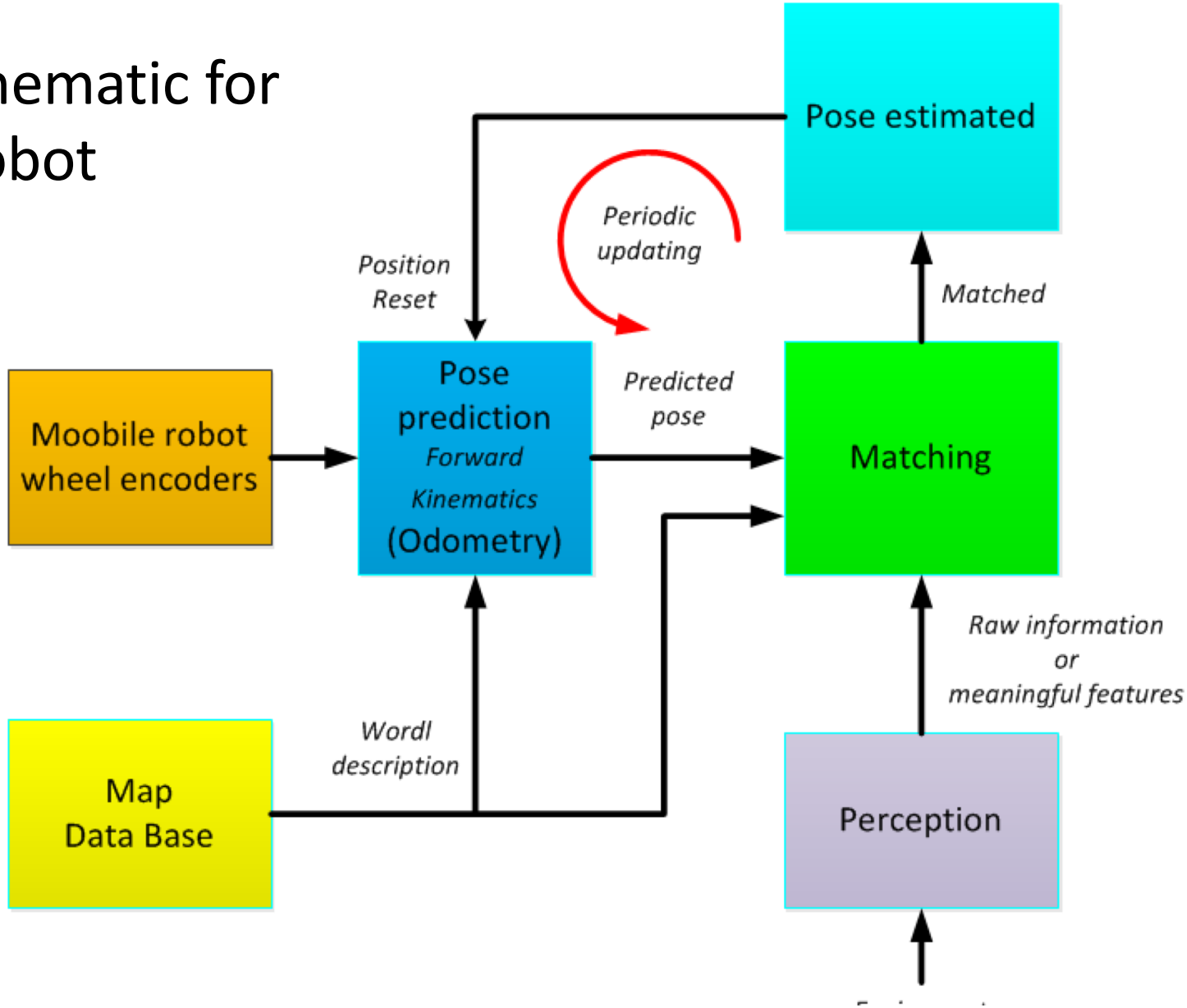
Automàtica i Informàtica Industrial

Mobile robot localization

General schematic for updating robot position



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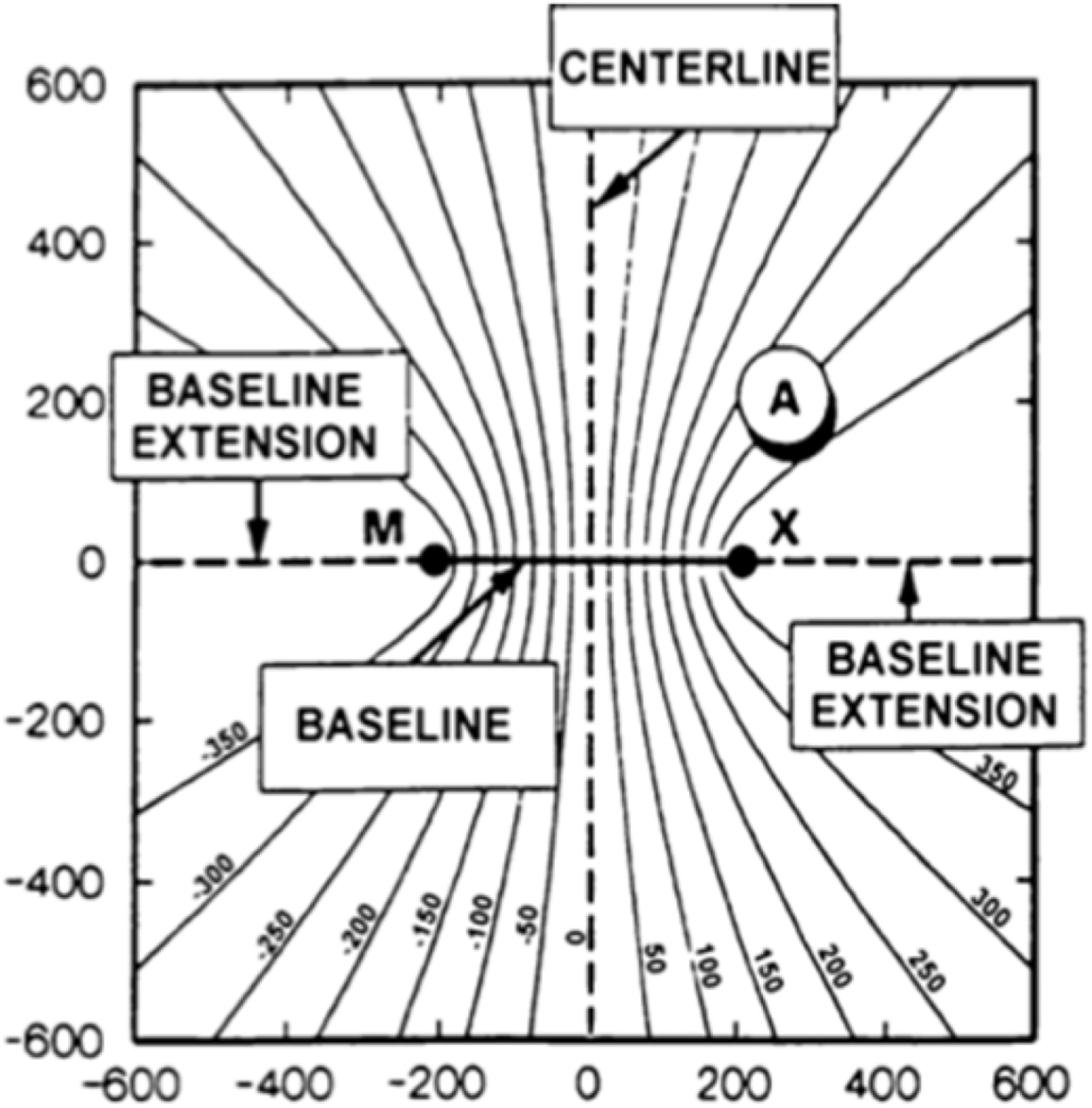
Loran Navigation



DATA

1. Known Base position $\{M, X, Y \ldots\}$
2. Arrival time differences between simultaneous emitted signals

$$d_{MA} = \sqrt{(x_a - m_x)^2 + (y_a - m_y)^2}$$

$$d_{XA} = \sqrt{(x_a - X_x)^2 + (y_a - X_y)^2}$$

$D_1 = d_{MA} - d_{XA}$; Hiperbolic line

1 Equation 2 unknwon;

A third base Y is needed

$D_2 = d_{MA} - d_{YA}$

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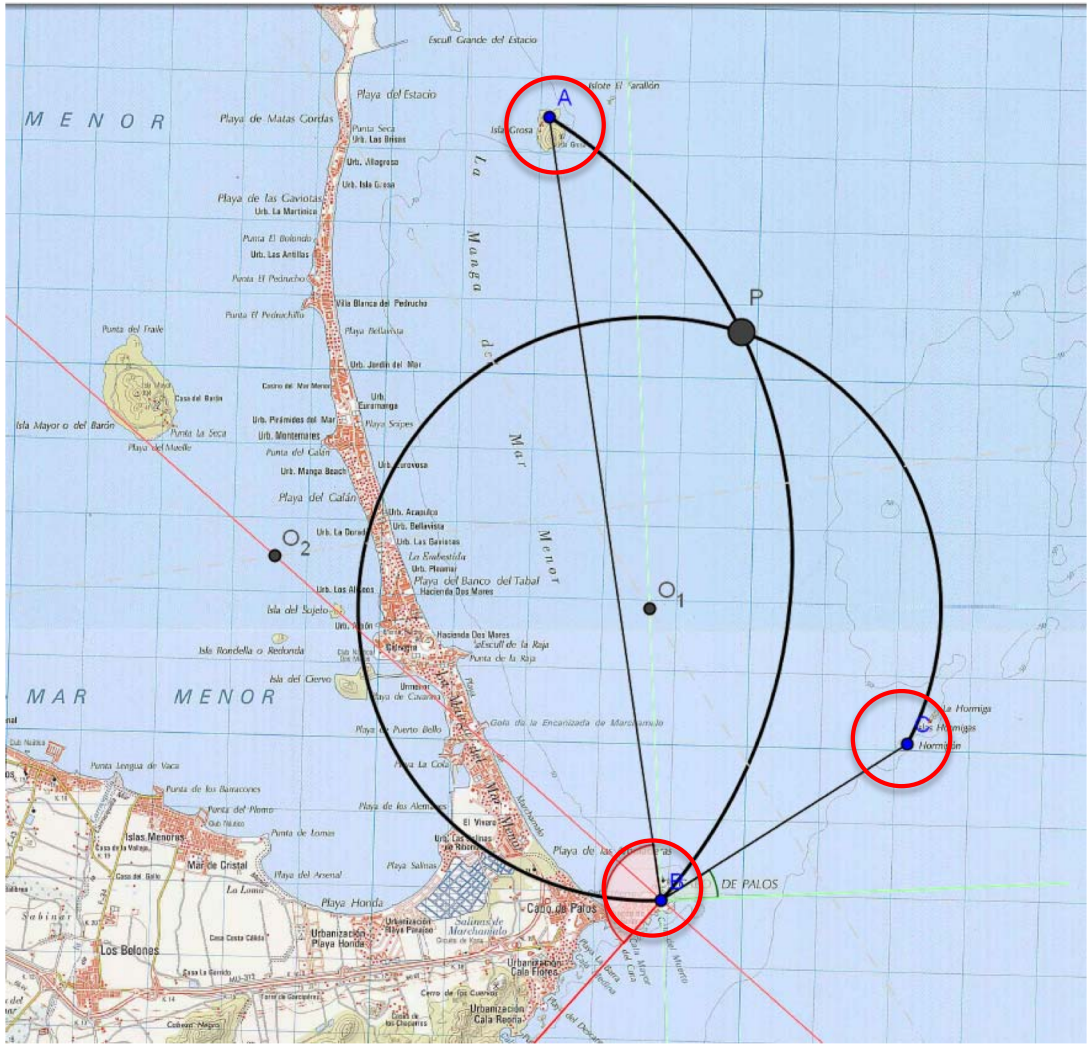
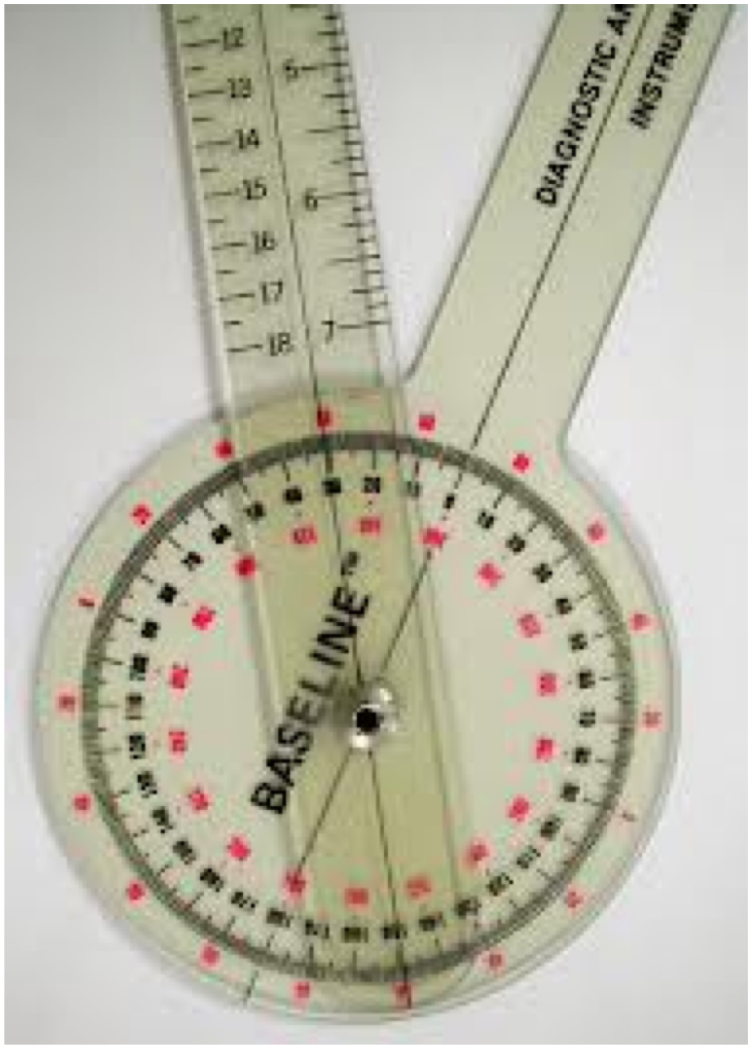
Global positionning using 'arco capaz'

It was used to situate very accurately a vessel near three visible objects whose position was accurately known.





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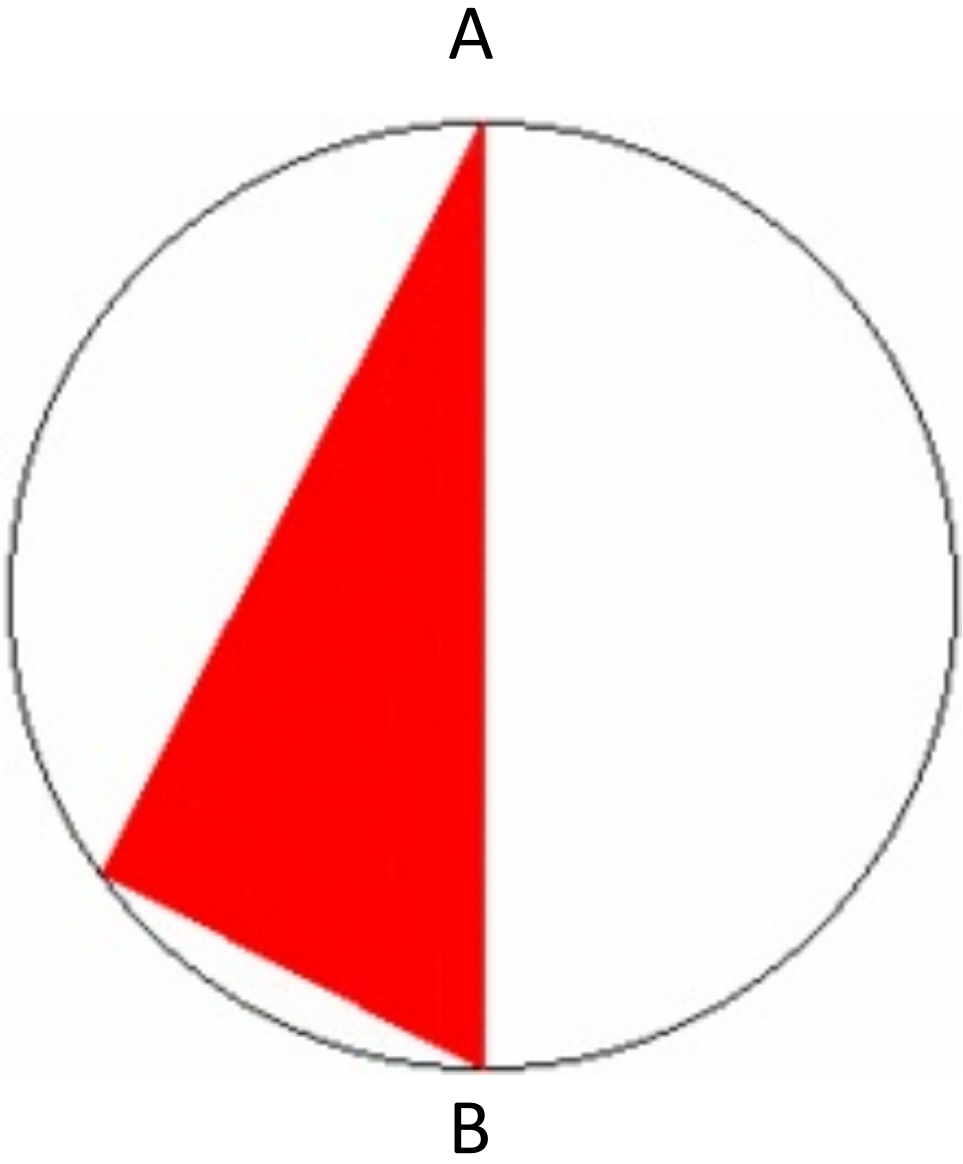
Global positionning

'Capacious arc'
'Spanning arc'
'Arco capaz'
"The geometrical locus of all the points from which a segment AB is seen under the given angle



'Arco capaz' for 90º

See 'arco capaz' animation in Wikipedia

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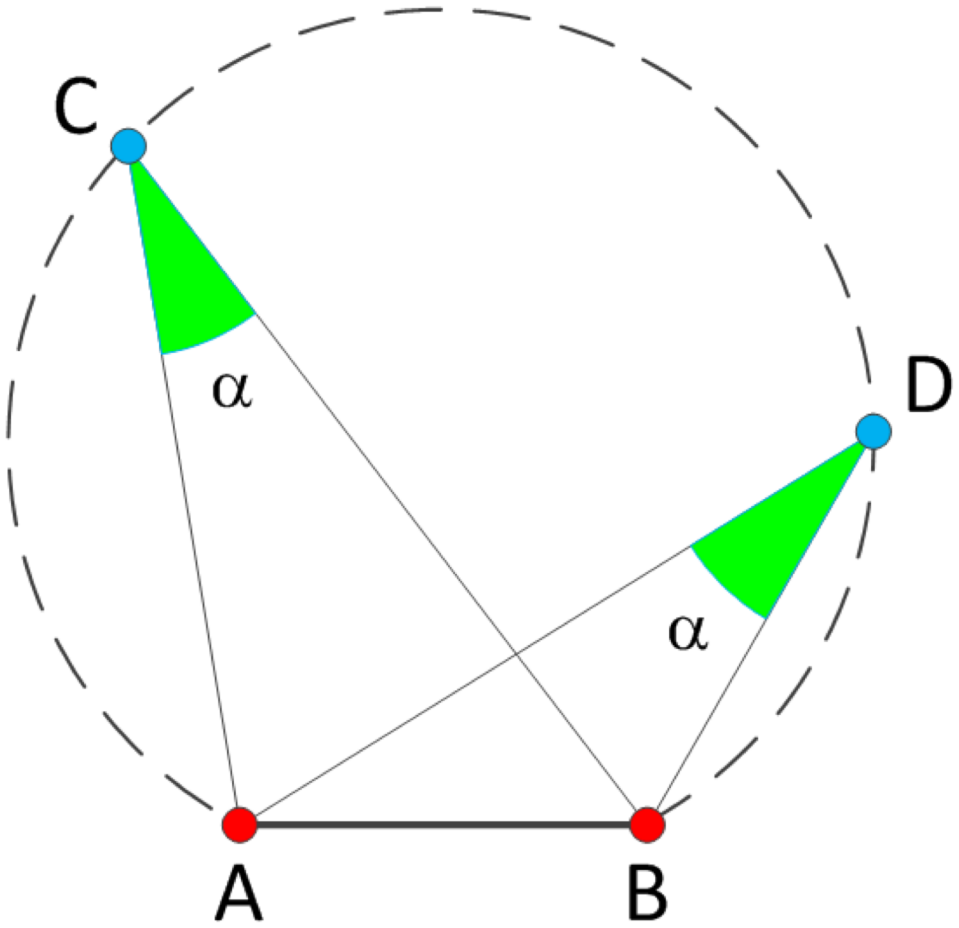
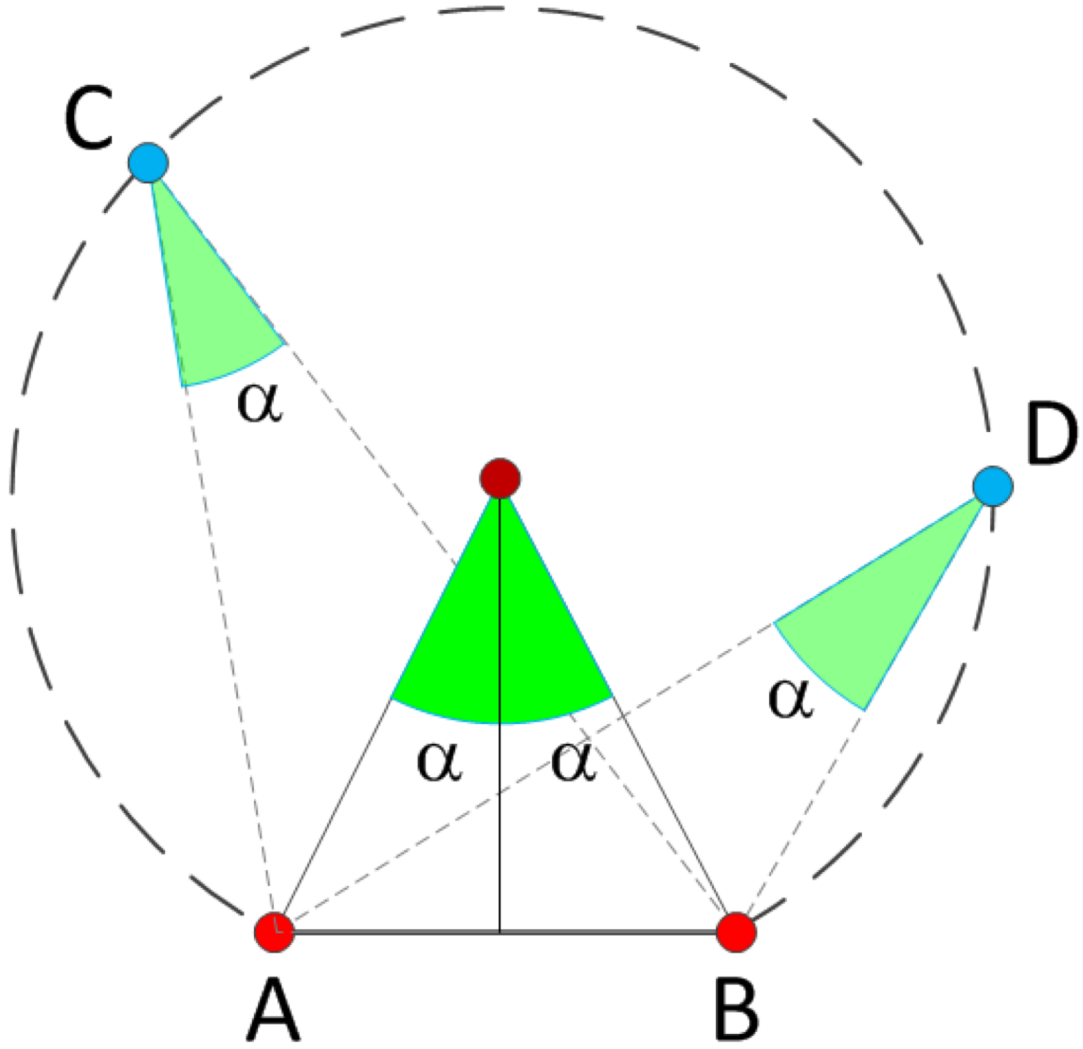
'Arco capaz'



From any point, C or D on the "arco capaz" the angle of secant lines:
CA and CB → ACB or the angle ADB must be equal to 'alfa'

'Arco capaz' properties



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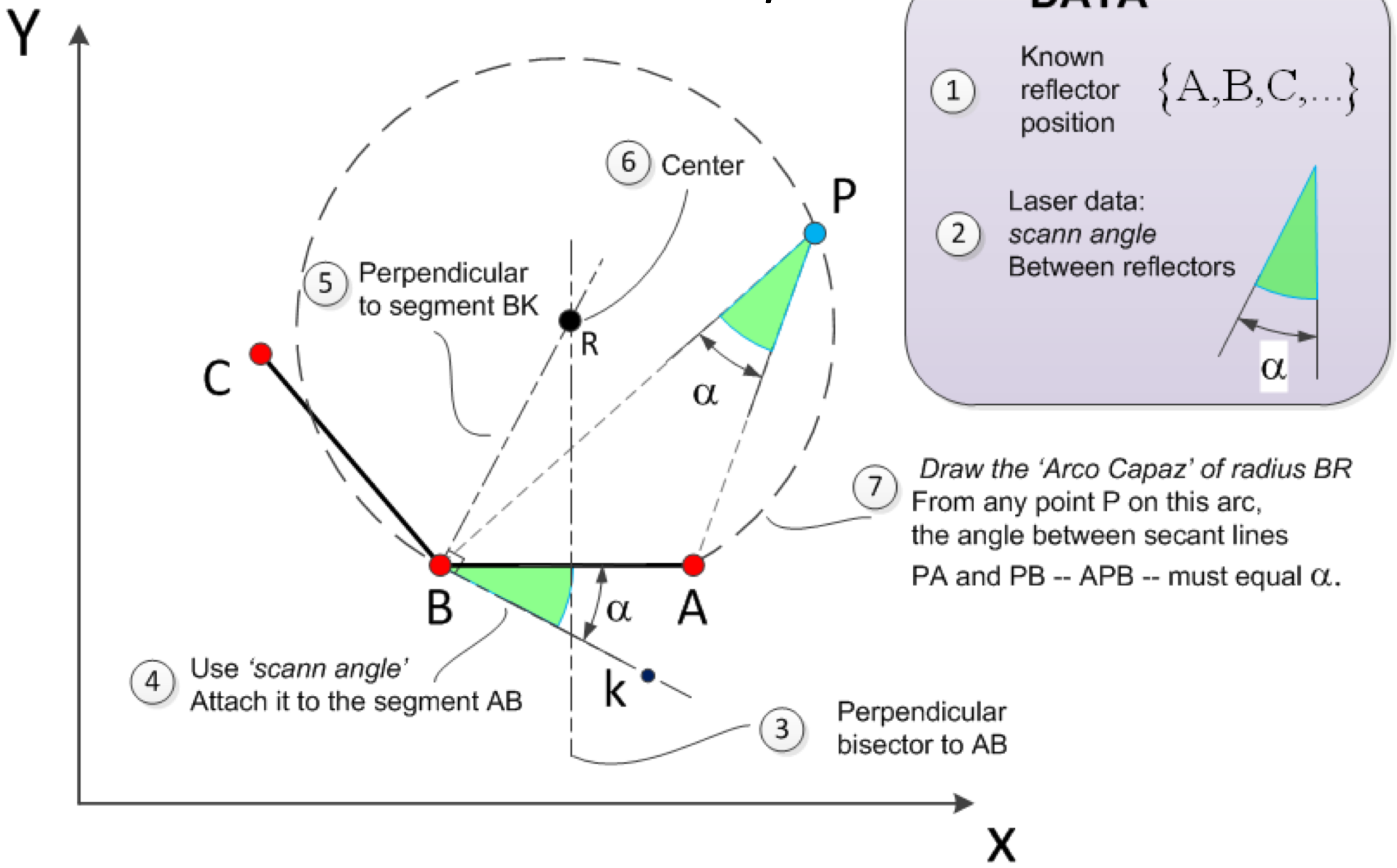
How to draw the 'Arco capaz'



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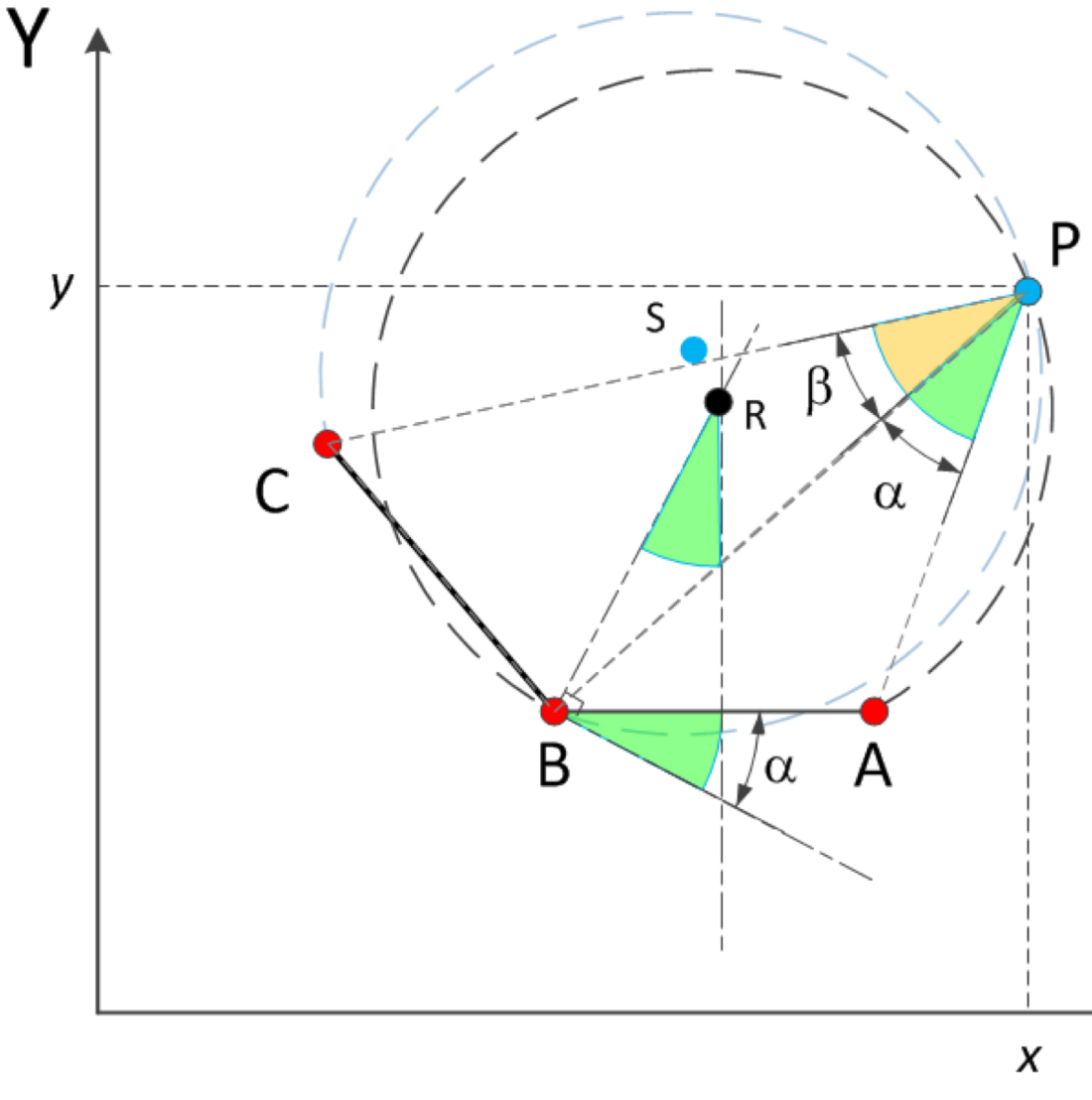
Finding the x,y coordinates

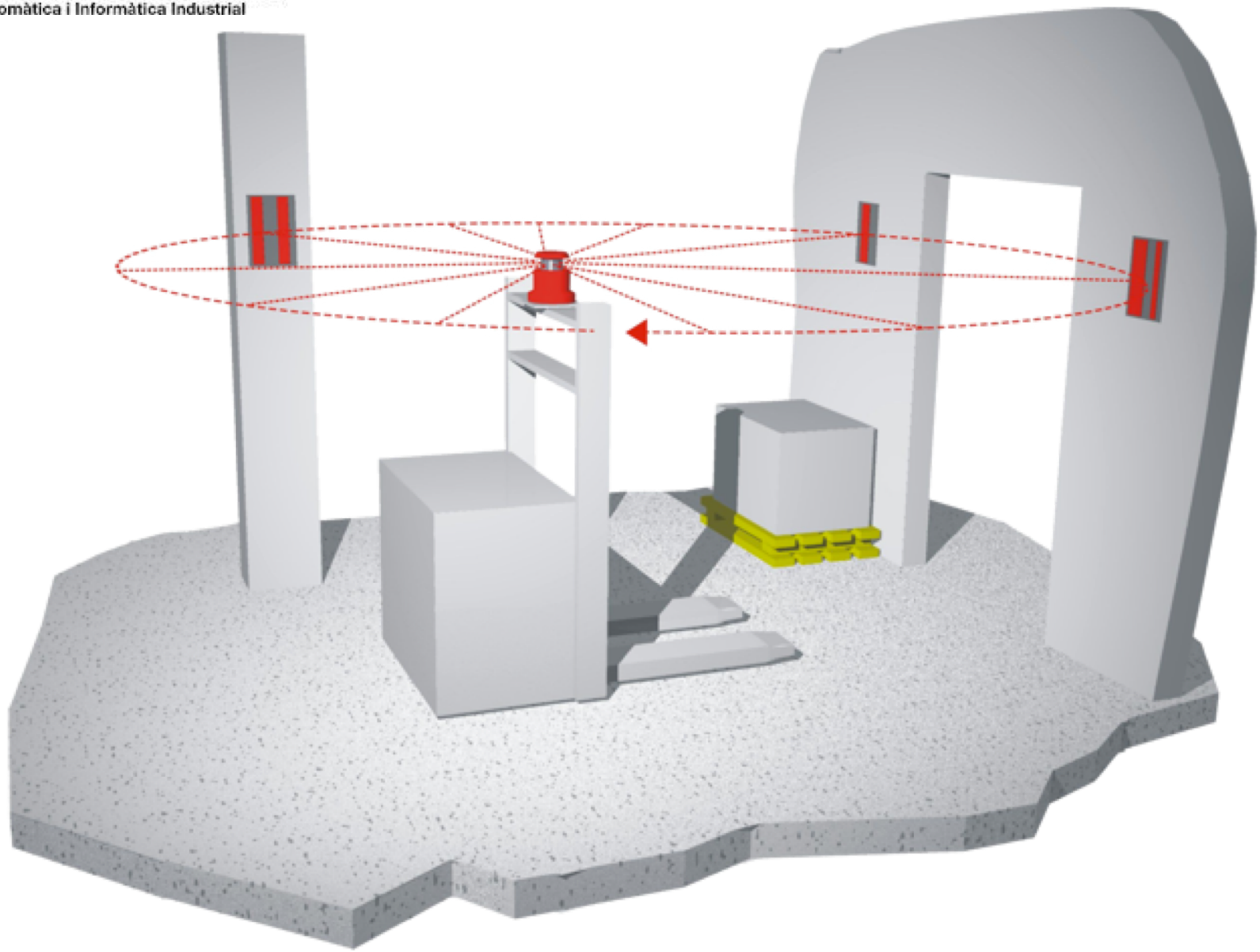


8 Repeat the same sequence for drawing the *'arco capaz'* who has radius CS and pass over C, P and B

9 'Arco Capaz' CPB:
From any point P on this arc, the angle between secant lines PC and PB -- CPB -- must equal β

10 Find the intersection of the two 'Arcos capaces'
One solution will be the coordinates of point B.
The other solution P satisfy the two scann angles

Laser goniometer



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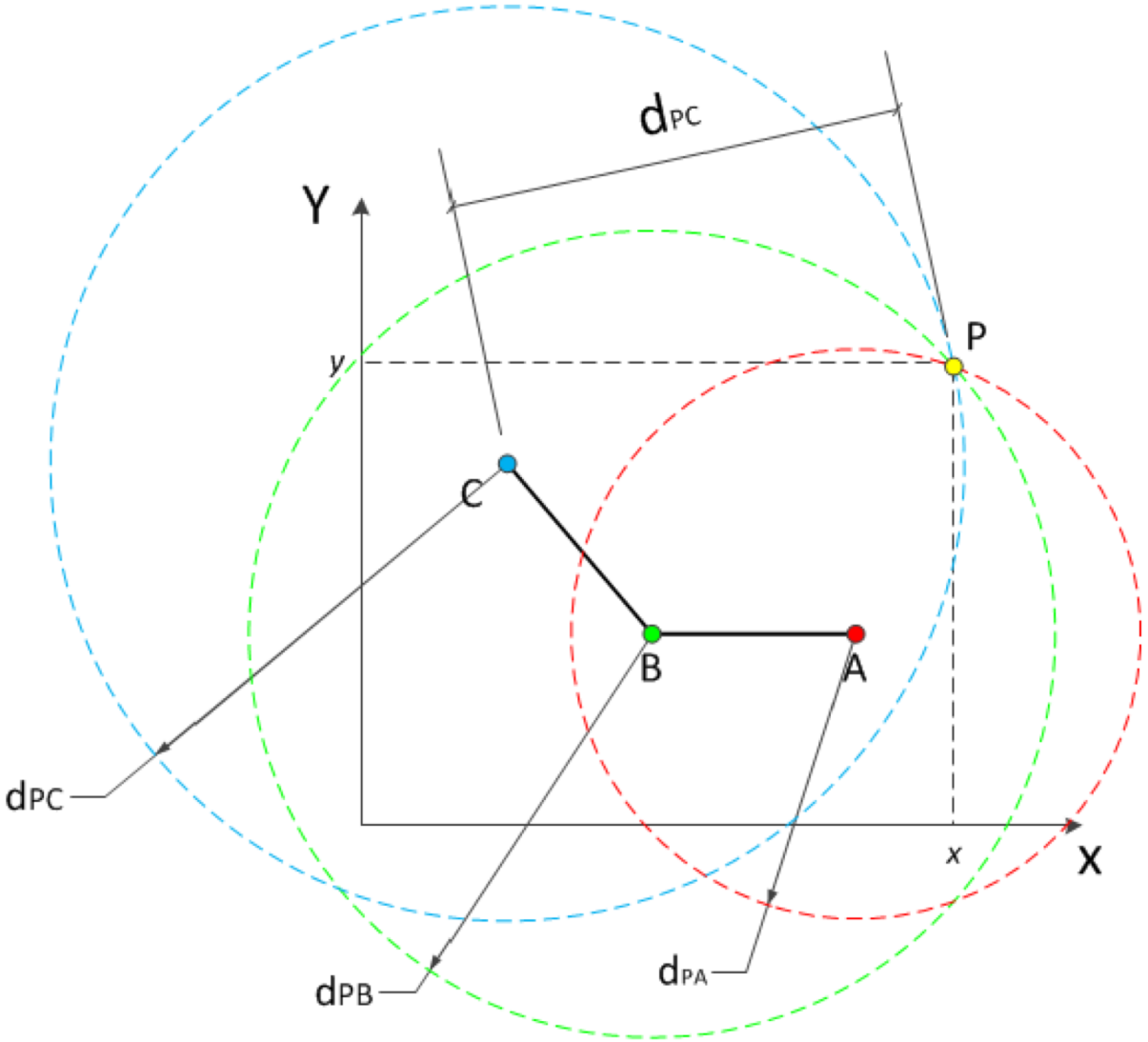
Signal strength & laser distance



DATA

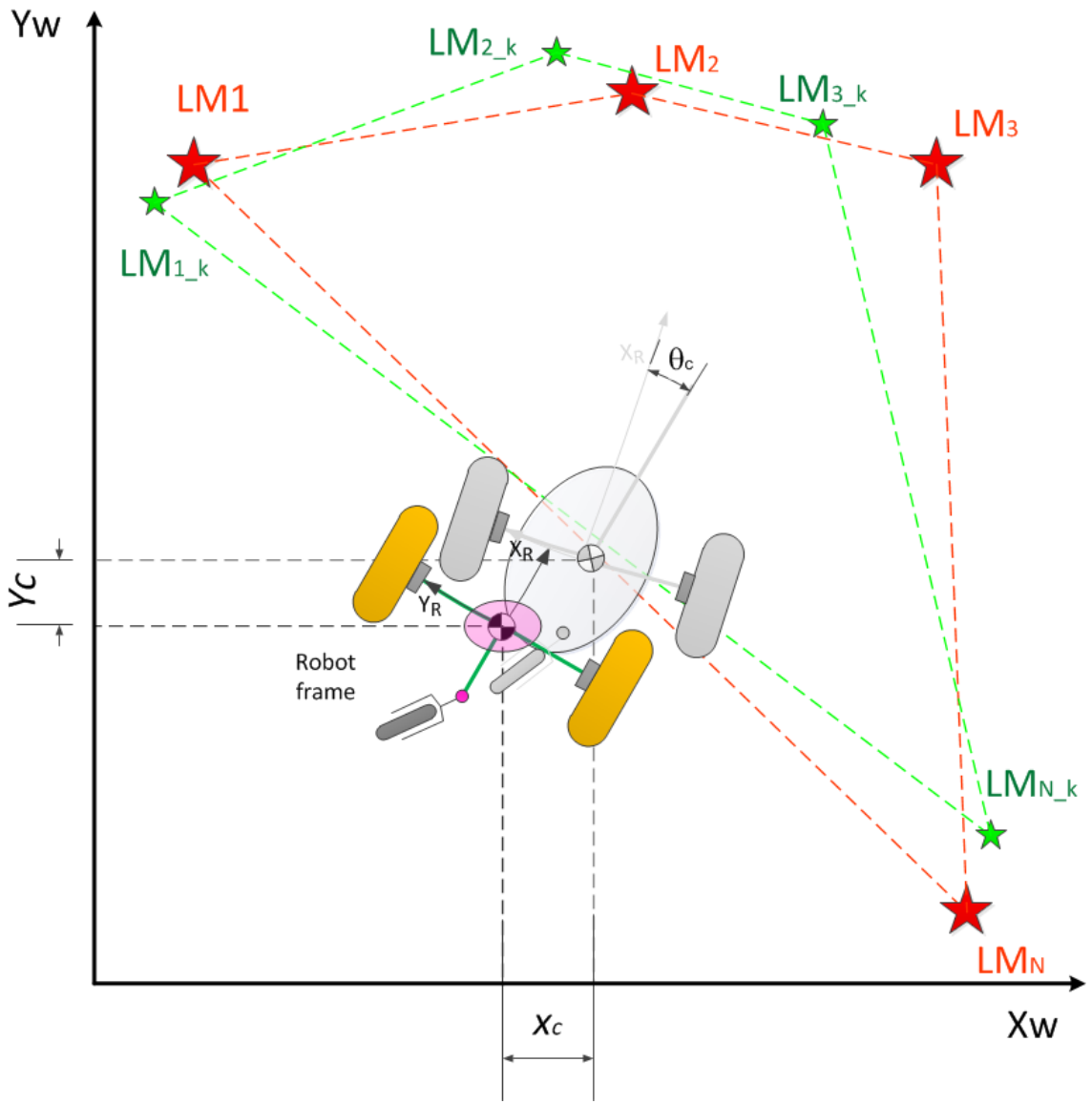
Known reflector or Emiters position $\{P,A,B,C,...\}$

Laser distance or signal strength $\{d_{PC}, d_{PB}, d_{PA}...\}$

Unknown

x, y

Localization: Similarity Transform



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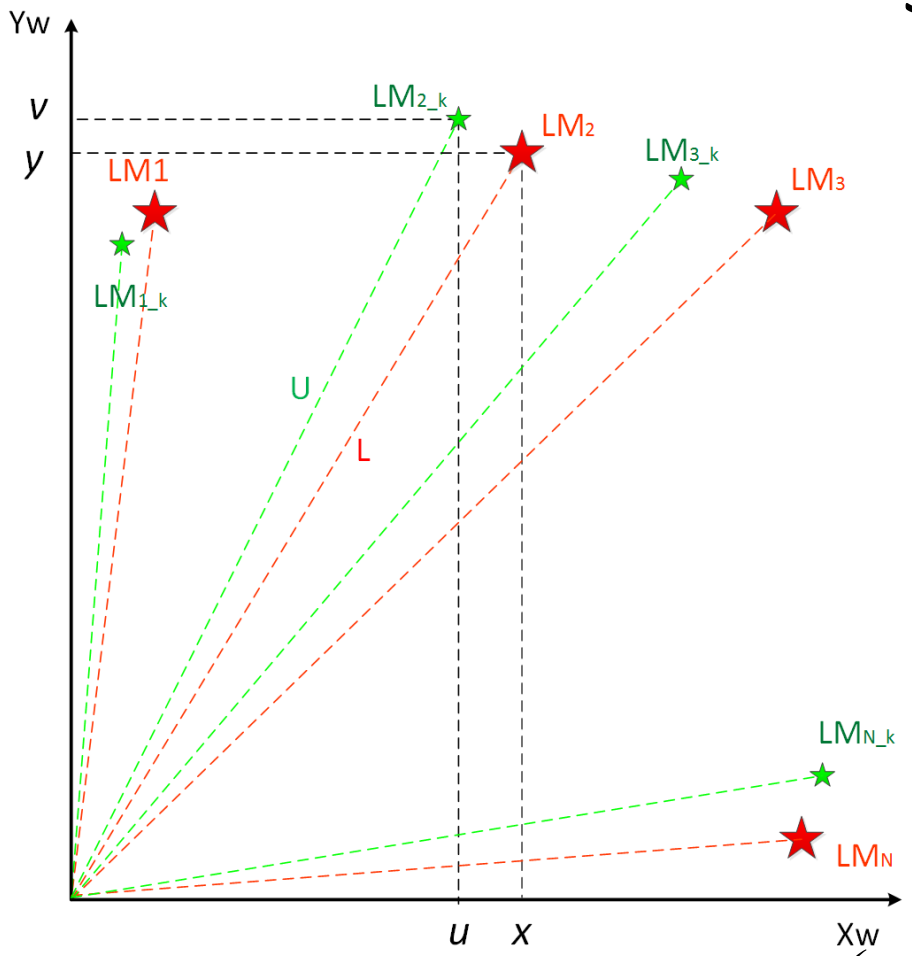
Similarity Transform



x;y is known; LM{1…N}

u,v is measured at tk; LM{1…N}

$$Rot_z(-\theta)L + transl(t_x, t_y) = U \rightarrow \begin{pmatrix} c\theta & s\theta & t_x \\ -s\theta & c\theta & t_y \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}_{3xN} = \begin{pmatrix} u \\ v \\ 1 \end{pmatrix}_{3xN}$$

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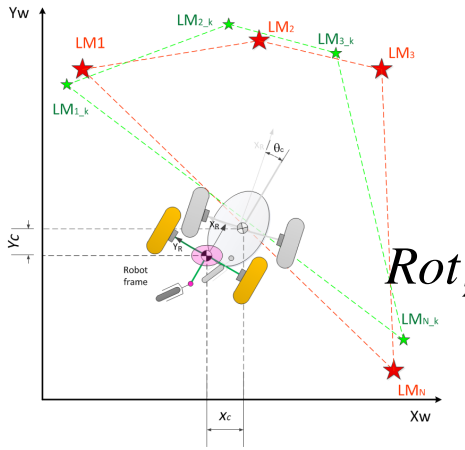
Similarity Transform



$$Rot_z(-\theta)L + transl(t_x, t_y) = U \rightarrow \begin{pmatrix} c\theta & s\theta & t_x \\ -s\theta & c\theta & t_y \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}_{3xN} = \begin{pmatrix} u \\ v \\ 1 \end{pmatrix}_{3xN}$$

Least squared is used to estimate the scale, rotation and translation parameters

$$\underbrace{\begin{pmatrix} x_1 & y_1 & 1 & 0 \\ y_1 & -x_1 & 0 & 1 \\ x_2 & y_2 & 1 & 0 \\ y_2 & -x_2 & 0 & 1 \\ \dots & \dots & 1 & 0 \\ \dots & \dots & 0 & 1 \\ x_n & y_n & 1 & 0 \\ y_y & -x_n & 0 & 1 \end{pmatrix}}_{A_{2nx4}} \underbrace{\begin{pmatrix} c\theta \\ s\theta \\ t_x \\ t_y \end{pmatrix}}_{\hat{X}_{4x1}} = \underbrace{\begin{pmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ \dots \\ \dots \\ u_n \\ v_n \end{pmatrix}}_{B_{2nx1}} \rightarrow A\hat{X} = B \rightarrow \hat{X} = (A^T A)^{-1} A^T B \rightarrow \begin{cases} \theta = \tan^{-1} \dfrac{\hat{X}_2}{\hat{X}_1} \\ t_x = \hat{X}_3 \\ t_y = \hat{X}_4 \end{cases}$$

Tracking lines (painted or magnetics) on the ground & RFID

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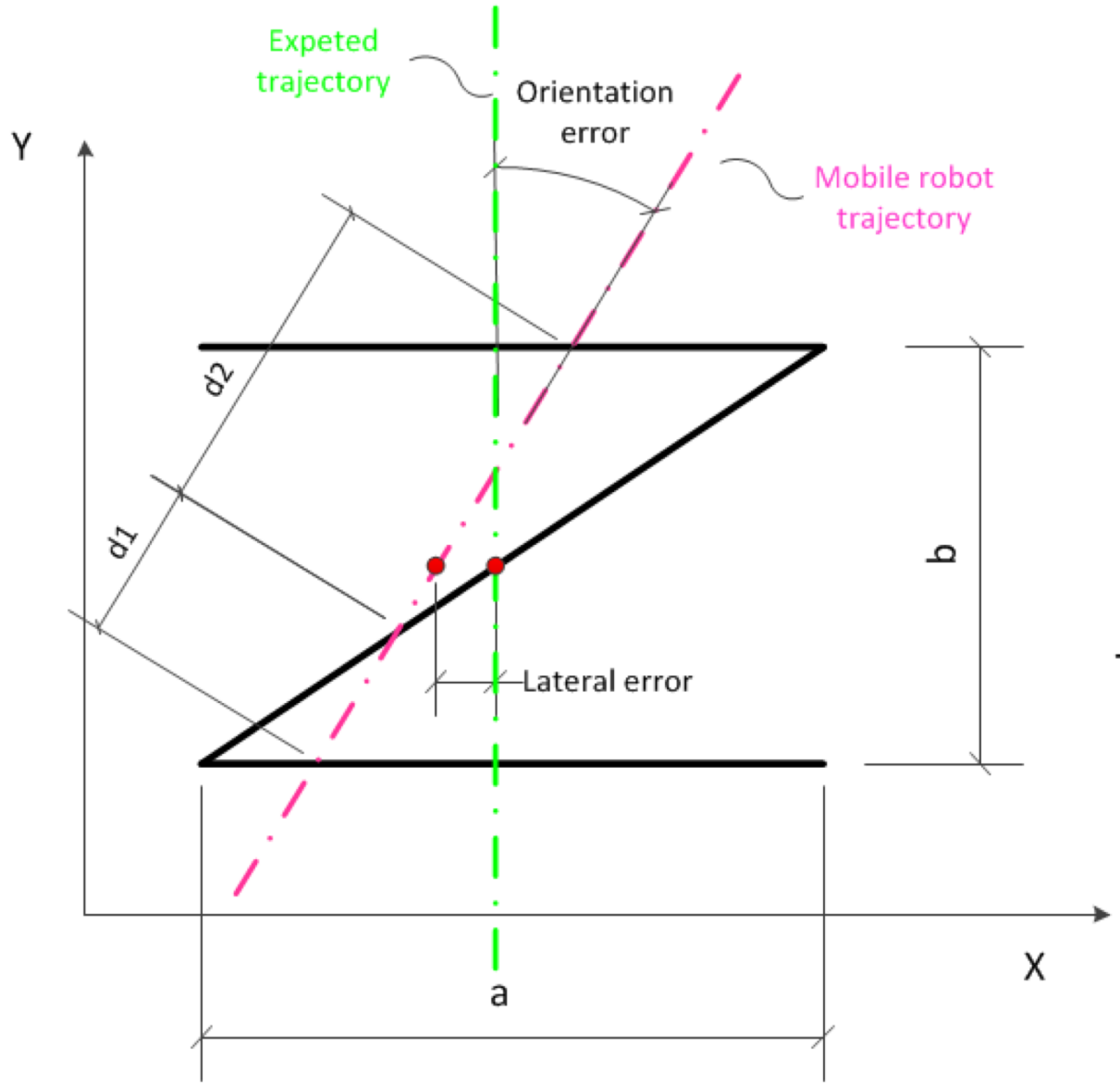
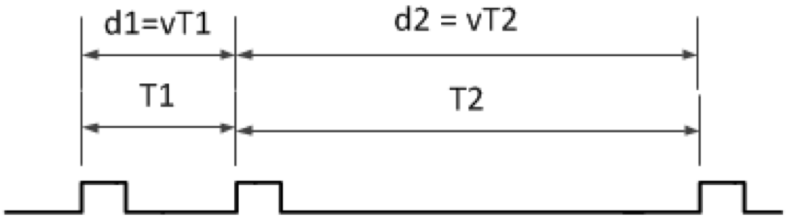
Z shape



Data:
- v: speed of the mobile robot
- Z shape geometry: a, b
- Z shape detection: T1, T2



Unknown
- Orientation error
- Lateral error