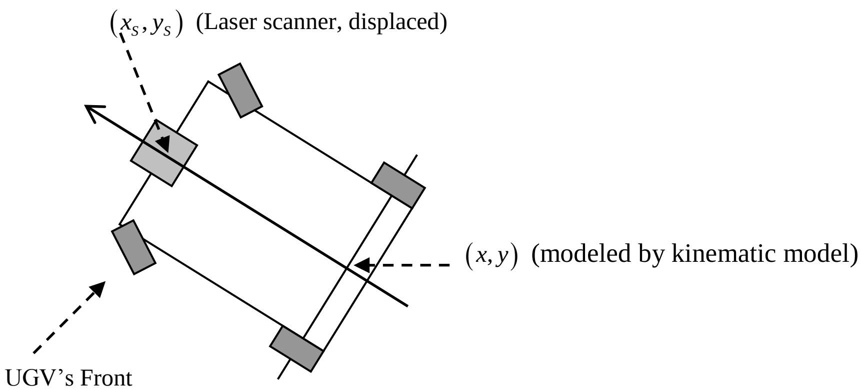
In this document, we discuss about certain necessary adaptations for our implementations in the projects. We need to adapt the estimator for the case of the laser scanner being located at a point which is not the one modeled by the kinematic model, e.g. the scanner is located at the front of the platform, approximately 46 cm ahead the point (x,y) which is estimated by the process. The laser is perfectly aligned with the platform (it only has a shift, longitudinally, on the platform body).



The shift, ***d***, is about 46 cm (approximately).

Note that we can solve this problem in different ways.

1) By adapting the observation function. In this case you replace the original observations functions by new expressions. It is worth mentioning that the modifications are also affected by the axis convention you use. The modified equations are the following ones,

$$h(\mathbf{X}) = \begin{bmatrix} h_1(x,y) \\ h_2(x,y) \end{bmatrix} = \begin{bmatrix} \sqrt{(x_a - x_s)^2 + (y_a - y_s)^2} \\ \tan^{-1}(y_a - y_s, x_a - x_s) - \phi + \pi/2 \end{bmatrix} = \begin{bmatrix} r \\ \alpha \end{bmatrix}$$

$$x_s = x + d \cdot \cos(\phi)$$
$$y_s = y + d \cdot \sin(\phi)$$
$$\Downarrow$$

$$\begin{bmatrix} \sqrt{(x_a - x - d \cdot \cos(\phi))^2 + (y_a - y - d \cdot \sin(\phi))^2} \\ \tan^{-1}(y_a - y - d \cdot \sin(\phi), x_a - x - d \cdot \cos(\phi)) - \phi + \pi/2 \end{bmatrix} = \begin{bmatrix} r \\ \alpha \end{bmatrix}$$

In which the constant ***d*** represents the longitudinal shift of the laser scanner.

The variables (x_s, y_s) represent the position of the laser scanner, which is now not exactly at the point (x, y), but a point displaced a distance ***d***, in the longitudinal direction of the platform. This implies that we need to adapt the EKF update stage to consider this new observation function, e.g. calculate the Jacobian matrix for this new observation function. (We may use the one we got before, free of shift, and apply the "Chain rule", for evaluating the partial derivatives).

2) An alternative and easier way, could be implemented by modifying the measurements of range and bearing, to produce range and bearing for a virtual laser scanner, located at (x,y), by just applying some geometry. This is a trick which, in this case, would work adequately and allowing you to keep the EKF identical to the one you implemented for a laser scanner installed exactly at the point (x,y) (i.e. (0,0) in the platform's frame). However, some disadvantages may arise in other cases (to be discussed in class).

3) Modelling the point where the laser scanner is located. In this case, a modified Kinematic model would be needed (To be discussed in class / solved by students if interested on it).

Note 1:
We indicated the bearing observation function as being: $\tan^{-1}(y_a - y_s, x_a - x_s) - \phi + \pi / 2$
Depending on the coordinate frame convention, it may be $\tan^{-1}(y_a - y_s, x_a - x_s) - \phi$
or a different one. It depends on the convention you use.
In addition, the term $\tan^{-1}(y_a - y_s, x_a - x_s)$ actually is the argument of the 2D vector $(x_a - x_s, y_a - y_s)$, which can be obtained using the function *atan2*, in Matlab.

Parameter identification

If the parameter ***d*** were not given, or it is not well known, it could be estimated by an approach similar to the one applied to estimate (on-line) the gyroscope's bias. However, this is not required in our projects. For doing it, we would need to consider the approach recommended in (1) and consider the parameter ***d*** as an additional system state, whose dynamic model would be perfectly described by the equation ***d(k+1)=d(k)***. (we explain this concept, in generalized terms, in the next lecture)
