Algorithm of Finding the Position of Segbot on X-Y Plane

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The self-balanced Segbot can be considered as a two-wheeled inverted pendulum model shown in Figure 1.

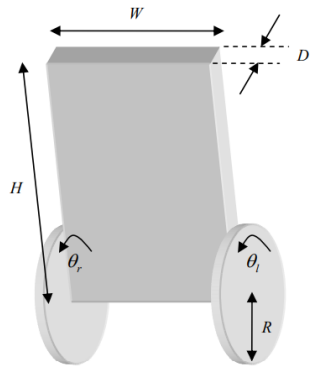

Figure 1 Two-wheeled inverted pendulum

Figure 2 shows the plane view of the two-wheeled inverted pendulum.

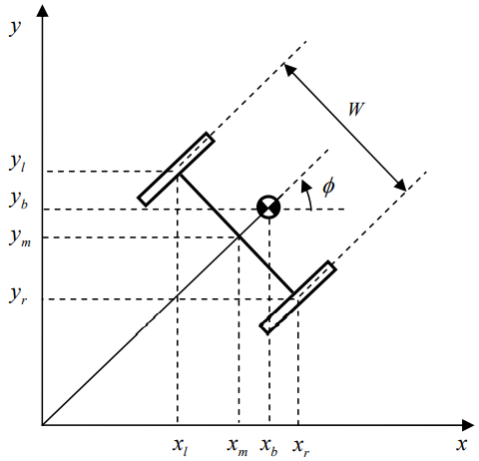

Figure 2 Plane view of two-wheeled inverted pendulum

Physical parameters of Segbot are following:

$W = 0.182$	[m]	:	Distance between the centers of the two wheels
D	[m]	:	Body depth
H	[m]	:	Body height
$\theta_{l,r}$	[rad]	:	Left/ Right wheel angle
$R = 0.0325$	[m]	:	Wheel radius
$x_{l,r}$	[m]	:	Left/ Right wheel position in X axis
$y_{l,r}$	[m]	:	Left/ Right wheel position in Y axis
x_m	[m]	:	Wheel axle midpoint position in X axis

y_m	[m]	:	Wheel axle midpoint position in Y axis
x_b	[m]	:	Segbot gravity center position in X axis
y_b	[m]	:	Segbot gravity center position in Y axis
ϕ	[rad]	:	Body yaw angle (from X axis)

(W is measured manually. R is measured by calculating the wheel angle difference before and after the Segbot move 1ft forward)

Kinematic equations for calculating X, Y position of Segbot (x_m, y_m) is shown below.

$$(\theta, \phi) = \left(\frac{1}{2}(\theta_l + \theta_r) \quad \frac{R}{W}(\theta_l - \theta_r)\right) \tag{1}$$

$$(\dot{x_m}, \dot{y_m}) = \left(R\dot{\theta}\cos\phi \quad R\dot{\theta}\sin\phi\right) \tag{2}$$

$$(x_m, y_m) = \left(\int \dot{x_m}dt \, , \int \dot{y_m}dt\right) \tag{3}$$

Where θ is the average angle of left and right wheel.

The body yaw angle ϕ is determined by the difference of two wheel angles. $(\theta_l - \theta_r)$ is the angle which the left wheel turns more than the right wheel. Suppose the left wheel move in a circle with the right wheel as the circle center. The Segbot turns $\frac{R}{W}(\theta_l - \theta_r)$ in angle.

$R\dot{\theta}$ is the moving velocity of the segbot. The projection of velocity on the X axis and Y axis is the sub-velocity on the X axis and Y axis. By integrating the two sub-velocity, the coordinates of Segbot on the X-Y plane will be obtained.

Links to references:
NXTway-GS Model-Based Design - Control of self-balancing two-wheeled robot built with LEGO Mindstorms NXT -