Motivation and Objectives

Airborne Networks (ANs) have gained dramatically growing interest over the years because of the advantages such as transportability, flexibility, and broad-coverage. Due to the need for aerial vehicles to perform time-critical tasks, vehicle-to-vehicle communication with low-delay and high throughput becomes necessary. Furthermore, there is growing need to connect aerial and ground networks to form on-demand multi-domain communication networks, for military and civilian applications when satellite communication is unavailable, gets highly disrupted, or does not meet the capacity and time-delay constraints.

Implementation and Tracking of RD Model

The built-in encoders in LEGO robots are used to track the distance travelled (d) and heading changes (β).

\[
\begin{align*}
\text{d} &= \text{enc}_{\text{count}} \times \frac{2\pi}{\text{enC}_\text{wheels}} \\
\beta &= \frac{\text{enc}_{\text{count}}}{2} \times \frac{2\pi}{\text{enC}_\text{wheels}}
\end{align*}
\]

The robots’ locations are tracked with following formula:

\[
\begin{align*}
\chi_k &= [\chi_{k-1} + d_k \cos \phi_k] \\
\psi_k &= [\psi_{k-1} + d_k \sin \phi_k]
\end{align*}
\]

where, \(\phi_k\) is the orientation of robot with x-axis. If robot hits the boundary condition then,

\[
\begin{align*}
\chi_k &= \chi_{k-1} + d_k \\
\psi_k &= \phi_k + (d_k - d_k') \cos \phi_k
\end{align*}
\]

Implementation and Tracking of Smooth Turn Mobility Model

To implement the ST model, we have both wheels rotate at different speeds determined by the turning radius (r), constant velocity (v) and length of robot (l).

\[
\begin{align*}
\omega_y &= \frac{v}{2} \\
\omega_x &= \frac{v}{2} - \frac{l}{2} - \frac{r}{2}
\end{align*}
\]

The robots’ locations are tracked using the Rotation Matrix concept given by:

\[
\begin{align*}
\chi_k' &= \left[ \chi_{k-1} \cos \phi_{k-1} \sin \phi_{k-1} \right] + \delta_k \left[ \frac{\cos \phi_{k-1}}{2} \cos \phi_{k-1} \right] \\
\psi_k' &= \left[ \psi_{k-1} \sin \phi_{k-1} \cos \phi_{k-1} \right] + \delta_k \left[ \frac{\cos \phi_{k-1}}{2} \sin \phi_{k-1} \right]
\end{align*}
\]

Prototype of the UAV Robot

The prototype of the UAV robot is equipped with the directional antenna, the linear actuator, and the wings.

Bank angle calculation:

\[
\tan \theta = \frac{\text{dis}}{2}
\]

Multi-Domain Communication

In the LEGO test-bed, we use Bluetooth and Xbee communication technologies. The UAV robot (which follows the ST mobility model) is equipped with the directional antenna Yagi-Uda to communicate with ground robots (which follow the RD mobility model) using the Xbee technology. The ground robots communicate among each other using Bluetooth.

Search and Rescue Scenario

In this scenario, we have two groups of ground vehicles where each group has two robots. All the robots search for the targets on their own. The two groups are far away from each other devoid of direct intra-group communication, but robots in their respective groups communicate. To enable the intra-group communication and to permit broad search coverage, an unmanned aerial vehicle (UAV) serves as the communication relay. Whichever robot finds the target will inform its group members using Bluetooth, inform other group robots via the UAV using Xbee, and also send the coordinates of the target that has been found. Then all the robots will swarm towards the target.

Ongoing Work

Replicating the antenna configuration directly in a small-scale test-bed is difficult, as the physical size and construction materials of our antennas and robots do not scale to full size vehicles and the frequencies used. In the spirit of keeping the test bed versatile, we will implement software modeling scheme to determine the expected signal strength of the communication links in a real-scale deployment.

References