UWB Tracking Software Development

Abstract

An Ultra-Wideband (UWB) two-cluster Angle of Arrival (AOA) tracking prototype system is currently being developed and tested at NASA Johnson Space Center for space exploration applications. This talk discusses the software development efforts for this UWB two-cluster AOA tracking system. The role the software plays in this system is to take waveform data from two UWB radio receivers as an input, feed this input into an AOA tracking algorithm, and generate the target position as an output. The architecture of the software (Input/Output Interface and Algorithm Core) will be introduced in this talk. The development of this software has three phases. In Phase I, the software is mostly Matlab driven and calls C++ socket functions to provide the communication links to the radios. This is beneficial in the early stage when it is necessary to frequently test changes in the algorithm. Phase II of the development is to have the software mostly C++ driven and call a Matlab function for the AOA tracking algorithm. This is beneficial in order to send the tracking results to other systems and also to improve the tracking update rate of the system. The third phase is part of future work and is to have the software completely C++ driven with a graphics user interface. This software design enables the fine resolution tracking of the UWB two-cluster AOA tracking system.
UWB Tracking Software Development

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Introduction

- An Ultra-Wideband (UWB) two-cluster Angle of Arrival (AOA) tracking prototype system is currently being developed and tested at NASA Johnson Space Center for space exploration applications.

- This talk discusses the software development efforts for this UWB two-cluster AOA tracking system.
Introduction

- UWB is an emerging communications technology unlike traditional Continuous Wave (CW) narrow band systems. The technology was approved by FCC in February 2002.

- Features: High data rate, fine time resolution and low power spectral density.

- UWB system is used for communications with added passive tracking

![Sinusoidal, Narrowband](image1)

![Impulse, Ultra-Wideband](image2)
Overview

- Useful for tracking rovers and astronauts for early Lunar/Mars exploration missions when navigation systems (such as GPS) are not available

- SCOUT vehicle as test-bed for Lunar/Mars rover prototype

- Excellent tracking performance with less than 1% error at ranges up to 2000'
Overview

- Utilize commercially available UWB radios and customize for our specific applications
- Radios are development kits and are not plug and play
- Radios essentially transmit and receive an UWB signal
- To use the radios:
  - Develop the Algorithm
  - Develop the Software
  - Develop the Hardware
Functionality of the UWB Tracking Software

Input: Waveform data from Rxs

Algorithm: Takes data from Rxs and calculates position of Tx

Output: Position of Tx

Software:
Goal is to track the position of the rover

A transmitter and an antenna are located on the rover

Four antennas, two receivers, a hub, and a laptop at the base station

Base station is divided into two clusters, each with two antennas and one receiver

The role the software plays in this system is to take waveform data from two UWB radio receivers as an input, feed this input into an AOA tracking algorithm, and generate the target position as an output.
Architecture of UWB Tracking Software

Input: Waveform data from Rxs
Core: Algorithm takes data from Rxs and calculates position of Tx
Output: Position of Tx

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Input Core Output
Waveform data Position data
The architecture of the software includes the Input/Output Interface and the Algorithm Core.

Input:
- Waveform data containing timing information received from four antennas

Core:
- AOA tracking algorithm
- Extracts timing information from waveform data and calculates position of transmitter

Output:
- Converts the position data into GPS coordinate system to track rover
- Plots and displays the position data to show accuracy of the system
Input:
Parallel Multi-Socket Programming

UDP Packet 1
UDP Packet 25

UDP Packet 1
UDP Packet 25
Waveform data is divided into 25 segments at radio

Software has a separate UDP socket for each of the two radios

Software collects one segment from one socket from receiver 1 and then takes one segment over the other socket from receiver 2

This alternating process is repeated until a complete waveform is assembled from each radio

The two radio are not synchronized. This process allows the collection and assembly of the waveforms at approximately the same instant in time to ensure the accuracy of the system
Phase I of UWB Tracking Software Development

Start

Matlab:
Algorithm

Mex

Array

Plot Position

End

C++:
Receive Data
Socket
Rx 1

Socket
Rx 2

 UDP Packet 1

UDP Packet 25

UDP Packet 1

UDP Packet 25

Form Array

Array
The software is Matlab driven with a C++ portion

The C++ part of the program is a Matlab Mex function which treats the C++ portion as if it were just a Matlab function

Matlab uses C++ to provide the communication links to the radios via UDP sockets

Beneficial in the early stage when it is necessary to frequently test changes in the algorithm, better to use Matlab

Drawbacks are the efficiency of opening and closing the sockets on each loop in Matlab – Also, plotting in Matlab takes up time
Phase II of UWB Tracking Software Development

**Diagram:**
- **Rx 1** connected to **Rx 2** via **Socket**.
- **UDP Packet 1** and **UDP Packet 25** received.
- **C++** process receives data.
- **Matlab** process calculates **X, Y**.
- **Matlab** plots vehicle position.
- **DLL** contains **Algorithm**.

**Processes:**
- **Receive Data**
- **Form Array**
- **Send Vehicle its Position**
- **Plot Position**