Leader Follower Convoy Using Zigbee Communication

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Abstract—In this paper there are two vehicles one is assigned as leader which has autonomous navigation system or this can also be controlled by remote host computer. The other vehicle is assigned as follower which can be called as a passive vehicle which just follows the leader trajectory by using a camera which gives feedback path to the follower to be aligned with the leader. Both Leader and the Follower vehicles make use xbee communication to talk to each other, there are one xbee module on leader and one at the follower, one more xbee module is used if the leader is controlled by the host computer.

Keywords—Xbee, X-CTU, Convoy, Ground Vehicles Camshift.

I. INTRODUCTION

Over past few years research trend has emerged that seeks to actively revolutionizing mobility as we know it, research to develop autonomous ground vehicles. Numerous companies and agencies around the world are working towards developing automated solutions for a variety of applications that seek to benefit military and civilian interests. In recent years the fruits of this labor have begun to work their way out of the lab and into active use.

From automated vehicle parking to autonomous convoying, the growing applications seek to increase system efficiency and raise the capability of human operators by offloading trivial or tedious tasks to automated systems. This has the ability to transform a variety of resource mobility processes by lowering the level of active human participation needed for a task, allowing operators to focus on other responsibilities. Additionally, by allowing autonomous systems to govern locomotion, the amount of error caused by human intervention or distraction will be reduced, thus lowering vehicle collisions while increasing overall efficiency.

Though the recent developments in robotic convoy technology are focused on more than military logistics applications, the EU-financed Safe Road Trains for the Environment (SARTRE) project aims to allow for normal motorists to join into an ad hoc convoy commanded by a professional driver [3]. After joining the platoon, the vehicle will transition into an autonomous state and hold a set distance from the car before it as the unit progresses along the highway. The driver can stay in the platoon until the relevant exit is approached and then the car can disengage the platoon and transition back to human control for the remainder of the trip. This system, if successfully developed and adopted could revolutionize modern transport by lowering traffic fatalities from human error, increasing fuel economy, and freeing commuters to focus on things other than driving.

A. VEHICLE CONVOYS

The core of this logistics issue lie the convoy, a simple but effective manner of moving equipment and supplies over long ground distances using multiple vehicles and a set path. For this setup a simple Arduino Uno board with ardumoto is interfaced for controlling the vehicle movement on top of this shield a Xbee shield is mounted with a xbee-pro S2B which has decent data rate of 250kbps and line of sight range of 1km. We have used one vehicle as leader and other as a follower there can be one or more follower vehicle also.

The problem of designing force multiplying convoy system can be summarized into a set of simple requirements:

1. The lead vehicle, driven by a human, must be functionally identical to a normal convoy lead vehicle meaning that all moment-by-moment decisions for the following units must be separated from the duties of the lead driver.

2. The following units must be able to follow the path set by the lead vehicle and be able to maintain a semistatic distance with the unit before them.

3. In addition, the following units must be able to deviate from the set path in the case of dynamic conditions on the set path. After executing the deviation, the units must be able to return to the path proper at the set distance.

This project focuses on the implementation of requirements 1 and 2 to develop a functional two platform convoy system using two ground vehicles.

II. CONVOY VEHICLE SETUP

In this convoy, we have two ground platforms with known positions within a global coordinate frame. The platform positions are defined as \((x_i, y_i)\) for the master unit and \((x_{i+1}, y_{i+1})\) for the follower unit with orientation angles \(\theta_0, \theta_{i+1}\) and respectively. The angle of the direct line-of-sight between the vehicles is denoted as \(\sigma_{i,i+1}\) and has a desired length 0fd.
To implement the convoy logic needed for autonomous control a set of hardware and accompanying software must be acquired or created. For this project we opted to utilize pre-built readily available hardware which we assembled and looks as it is shown above. It has on board set of regulated voltage supplies for powering additional components that provides a nominal operation time of two hours and a peak power of 2.6mA

IV. GUIDANCE LAWS APPROACH

There are two basic subcomponents which were developed:

1) Tracking system capable of recognizing the leader and continually estimating the leader’s position, and
2) A follower vehicle capable of driving the leader’s trajectory.

A. Tracking using CAMShift algorithm

CamShift algorithm, namely Continuously Adaptive Mean-Shift method, is a real-time tracking algorithm. It uses color information to track the moving target and is mainly based on Back Projection calculation and Mean Shift algorithm [5,6].

a. Back Projection Calculation

The calculation step of Back Projection is described as follows.

1) Calculate the tracked target’s color histograms. In all sorts of color spaces, only the H component of HSV space or the H component of the color space which is similar to HSV space can express the color information. So in the process of calculation, the value of other space should be transformed into the value of HSV space at first and then 1D histogram calculation for the H component was performed (H, S, and V stand for hue, saturation and value respectively).

2) Transform the original image into color probability distribution image by the color histogram acquired.

b. Mean Shift Algorithm

Mean Shift algorithm, as a density function gradient estimate non-parametric method, is to locate the target by finding the probability distribution of extreme value through iterative optimization. Mean Shift algorithm calculates the mass center of the target area in an image. In the process of calculation, the size of the search window changed constantly until the variation of the mass center calculated was less than a given threshold, and the mass center of the target area was obtained.

c. Camshift algorithm

Transform Mean Shift algorithm to CamShift algorithm by expanding single image to continuous image sequence. The basic idea is to perform Mean Shift operation for all frames of video images. Choose the central position and the size of the search window of previous frame as the initial value of the next frame’s search window.
So the whole algorithm works as follows:

1) Read the first frame image of the video and extract the H component from HSV space.

2) Initial the search window, choose the target’s moving area and calculate the area’s color histogram.

3) According to the target area’s color histogram, get the probability distribution of the projection images of the current frame by making reverse projection.

4) According to the search window’s size and central position, perform Mean Shift operation for the probability distribution of the projection images and move the central position to the mass center’s position to acquire the mass center of the search window.

5) If the central position is not convergent, return to step 4 and calculate the mass center according to the central position until it is convergent when the area’s central position and size is the position and size of the target in the current frame. Return to step 2 and start a new round of calculation[8].

V. RESULTS

The vehicle uses four DC motors (geared) for driving the four wheels independently. The DC motors are controlled by a microcontroller. Visual tracking the most important block of the system gives the information about the leader vehicle, its relative distance and angular displacement. Using the camshift algorithm based on vision conjunction with OPENCV PYTHON, the convoy scenarios were investigated. The visually detected markers from the camera are shown in Figure 5. Table 1 illustrates the desired and estimated results for the relative distance estimation between the leader and the follower.

<table>
<thead>
<tr>
<th>Desired relative displacement</th>
<th>Obtained measurements</th>
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<tbody>
<tr>
<td>5cm</td>
<td>5.4cm</td>
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<td>10cm</td>
<td>11cm</td>
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VI. CONCLUSIONS

Design of an intelligent unmanned system for a leader-follower framework was performed and tested in a real time environment. The objective of the proposed method was to perform formation control using vision only follower. The proposed system on testing in real time environment proved to be accurate for outdoor environment condition under constant lightning condition. The scope of the proposed system can be extended for
各种闪电条件和不同速度的靶标。障碍传感器应该被添加以确保任何行人或车辆在领导和跟随者之间移动时不会被击中，视觉基线路径跟踪算法可以允许车辆在重复路径下更安全地保持在车道中心。

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