A GPS Based Approach for Autonomous navigation of UAV

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Abstract

Autonomous navigation for Unmanned Air Vehicles (UAVs) is challenging because the instruments used for sensing which are carried on-board should have very less dimensions, weight and power constraints. The developed autopilot navigation system should be robust against any real-world conditions and calculate the performance in any field tests. A GPS module is used that combines a baseband signal processing engine and a CMOS RF down-conversion circuitry which gives an excellent receiving performance. UAV’s are generally used in application which requires high altitude flight over any structures, hence the chances of GPS signal degradation is minimal. Here we present an autonomous Autopilot system suitable for use in UAVs or any Aerial vehicles that contains GPS as its primary sensing unit that replaces the existing Autopilot system architecture. This paper describes the development of an Aerial robot with an autonomous navigation system. Because of the size constraints and in UAV the common attitude control module can be removed and GPS can be used alone to get the control parameters of the UAV.

Keywords: Microcontroller, GPS, Autonomous Navigation, UAV.

1. Introduction

1.1 UAV

Unmanned Aerial Vehicles (UAV) have been around for more than a decade and they are increasing in numbers and are more effective with rapid development of technology, miniaturization of systems and with efficient control strategies. This has made the UAVs more smart and are now built with autonomy which extends it application beyond military and in civil industries. UAVs find its potential in domestic application to improve public safety and strengthen the benefits with in crop monitoring and disaster response and rescue operations and much more.

As much the application of UAVs are deployed the primary significance of UAVs are not lost in terms with surveillance, tracking and monitoring in any mission. The historic significance of UAVs dates back to World War period where they were controlled by radio control techniques which would carry explosive and or act as a self-destructive bomb in enemy region. Since then the autonomy of UAV has empowered in fields like agriculture, Coast guard, Power line inspection, Fire inspection and many more.

1.2 GPS

The Global Positioning System (GPS) is acquired from the ground stations through a constellation of 24 satellites which is positioned along the geostationary orbit and polar orbit. It is a worldwide radio-navigation system. To calculate positions, GPS uses these satellites as reference points and give accurate values in a matter of meters. GPS receivers has been scale down to just a miniature integrated circuits and are economical therefore makes the technology available to virtually everyone.

The GPS receiver module output an efficient and very compressed binary protocol by using its custom and exclusive firmware. The change between NMEA and Binary protocol by using with standard MTK commands or messages,

The GPS receiver module features a low noise amplifier and NVRAM, -165dBm sensitivity, USB or UART interface.

2. Proposed System Architecture

The Figure 1 shows the proposed system of the GPS based Autonomous navigation system. The GPS module is powered by 5V through LDO which is from the Power regulator module. The Microcontroller is a 32-bit controller which operates at 168MHz.
The GPS module is clocked at 32.768KHz and the communication between the sensor and Microcontroller is through UART protocol. The GPS used NMEA0183 protocol and is capable of working at different baud rate giving a flexible environment for the controller to establish communication.

The GPS can be refreshed at different rates to get updates at desired time. The available refresh rate are 1 Hz, 4 Hz, and 10 Hz. The different refresh rates can be selected by sending a command to GPS module through RX of the UART. The corresponding commands available are $PMTK221,100*2F$, $PMTK221,250*29$, $PMTK221,1000*1F$ which is used to set the GPS to 10hz, 4hz, 1hz and which updates every 100 milliseconds, 250 milliseconds, 1000 milliseconds respectively.

Different baud rates can be used for the communication and the baud rate can be changed by using the commands $PMTK252,4800*14$ to set 4800bps, $PMTK252,9600*17$ for 9600bps, $PMTK252,19200*22$ for 19200bps, $PMTK252,38400*27$ for 38400bps.

The customize commands can also be generated to create a specific command format to enable a desired output and to discard other output options. The National Marine Electronics Association (NMEA) format specified by MTK is shown in Table-1.

<table>
<thead>
<tr>
<th>Name</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message ID</td>
<td>SPGCMD</td>
<td>Customize command header</td>
</tr>
<tr>
<td>Command Number</td>
<td>15</td>
<td>This number symbolizes which command is used</td>
</tr>
<tr>
<td>RMC</td>
<td>0</td>
<td>The Period is from 0 to 5. where 0 mean to disable output</td>
</tr>
<tr>
<td>VTG</td>
<td>1</td>
<td>The Period is from 0 to 5. where 0 mean to disable output</td>
</tr>
<tr>
<td>GSA</td>
<td>0</td>
<td>The Period is from 0 to 5. where 0 mean to disable output</td>
</tr>
<tr>
<td>GSV</td>
<td>0</td>
<td>The Period is from 0 to 5. where 0 mean to disable output</td>
</tr>
<tr>
<td>GGA</td>
<td>1</td>
<td>The Period is from 0 to 5. where 0 mean to disable output</td>
</tr>
</tbody>
</table>

An Example that will enable all the messages options is $SPGCMD,15,0,1,0,0,1*7B$

The UART protocol used for the microcontroller requires to add “\r\n” at the end command for each line, to indicate next line in the command. For example if you want to send the message "$PMTK221,265*28" to the GPS unit, it will be:

```
HAL_UARTtransmit("$PMTK221,265*28\r\n")
```

The NMEA Output Sentence includes GGA, GSA, GSV, RMC and VTG. The descriptions of the options are shown below:

- **GGA** – Position, UTC Time and fix type data.
- **GSA** - Active number of satellites used for position solution, Operating mode of GPS receiver, and DOP values.
- **VTG** - Speed and Course data relative to the ground.
- **GSV** – Azimuth angle, elevation, the number of GPS satellites in view satellite ID numbers, and SNR values.
- **RMC** – Date, Time, Course, Position and speed data.

For the system proposed we require Time, Position, GPS fix, Azimuth angle, elevation, Speed data, Speed, Course relative to ground. Hence all the options are selected by sending the command as described above.

### 3. Methodology and Results

![Fig.2 Implementation of the Autonomous navigation System](image-url)
The UART peripheral is first initialized and then the GPS is initialized by sending the command through the UART. The GPS starts sending NMEA format packets, this raw data is sent through a parsing module where the required value of the parameters are isolated. These parameters are sent to the control code to get the yaw, pitch roll of the craft in flight. By using these data the UAV can be controlled through the flight. The UART peripheral is frequently checked for the next data and the process is repeated.

The GPS data logged from the sensor was displayed in the HyperTerminal through UART protocol at a baud rate of 115200 as shown in the Fig.4. The data parameters logged from the GPS are Latitude, Longitude, Altitude, Speed relative to ground, Course, UTC Time and GPS fix value. The GPS Position fix value indicates the Status of GPS. If it is ‘0’ then the Fix not available, if it is ‘1’ then the GPS is fixed and if ‘2’ Differential GPS fix

4. Conclusions and Future work

In this paper we have described a system which offer an accurate, low-latency redundant sensors to estimate motion and attitude of the UAV. By using a single ultra-compact GPS rather than using other nonlinear sensors, the autonomous navigation system becomes compact and hence reduce the overall dimension, weight and power utilization by the autopilot system which thereby increases the flight duration of UAV. A dynamic vehicle model can be used which allows the autopilot system to be repositioned easily and without any adaptation to other vehicles (aerial, ground or any autonomous vehicle).

To improve the correctness of the systems navigation measurements, and to decrease the computation time of the processor a higher processing controller can be used but it in turn it increases the cost of the overall system. An embedded system which has a DSP unit and with high-speed microcontroller can be used, to realize the complex processes of navigation and control and to implement camera interface. The GPS unit was used, to achieve a highly precise measurement quantity necessary for navigation such as position, attitude, course, but the initialization of the GPS takes around 20sec to couple of minutes depending on the environment conditions. This is the main drawback of this system which can be overcome by using a high fix GPS devices.

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References


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