Microcontroller Radar Stations utilizing Software Defined Radio (SDR)

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Purpose

- The goal of this research is to create portable radar systems that can be used in real life applications. This would allow in many fields of study to use very small microcontrollers to complete everyday task. Many devices would benefit of having an alternative portable system compared to a bulkier design. My goal is to create a reliable radar that can run nonstop without much down time and push the limits of how far different microcontrollers can perform in different real-world applications.
What is SDR?

- **Software Defined Radio** is a radio communication system where components that have been traditionally implemented in hardware are instead implemented by means of software on a personal computer or embedded system.

- **ADS-B** is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked.

- **MLAT system** is a navigation and surveillance technique based on measurement of the *times of arrival (TOAs)* of energy waves (radio, acoustic, seismic, etc.)
Block Diagram of Radar Stations

- Antenna
- RF Cable (N male to SMA male)
- RTL-SDR Dongle
- NooElec Filter
- Cloud Connection
- Raspberry Pi 4
- Local remote SDR operation/Personal laptop
- This is where we control the whole system
- Host Computer
Radar Stations
Remote Cloud Connections

VNC Viewer allows me to have access to any device on the cloud at any time.

Advantages of Creating my own Cloud:

- All devices can be updated simultaneously
- Can spot any errors or Security vulnerabilities in the software.
- Have access to any command window to any device.
FlightAware Interface

FlightAware control panel allows me to:

- Collect amount planes in the radius during a certain time.
- The direction of the signal when transmitted
- Make software updates to the piaware at any time.
FlightAware Interface

- The FlightAware Interface allows the user to receive information on different flights, Longitude, Latitude, and other stats on active flights.
- The system is full functional and has not crashed.
- Up for 500 days
Flight Statistics

AIRCRAFT REPORTED

<table>
<thead>
<tr>
<th></th>
<th>1/22/2020</th>
<th>1/21/2020</th>
<th>1/20/2020</th>
<th>1/19/2020</th>
<th>1/18/2020</th>
<th>1/17/2020</th>
<th>1/16/2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS-B Mode-S</td>
<td>795</td>
<td>2,515</td>
<td>2,347</td>
<td>1,592</td>
<td>1,512</td>
<td>2,121</td>
<td>1,801</td>
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<tr>
<td>MLAT</td>
<td>49</td>
<td>112</td>
<td>78</td>
<td>36</td>
<td>47</td>
<td>130</td>
<td>104</td>
</tr>
<tr>
<td>Other</td>
<td>76</td>
<td>196</td>
<td>169</td>
<td>200</td>
<td>186</td>
<td>270</td>
<td>273</td>
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<tr>
<td>Total</td>
<td>920</td>
<td>2,823</td>
<td>2,594</td>
<td>1,828</td>
<td>1,745</td>
<td>2,521</td>
<td>2,178</td>
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Positions Reported by Distance from Receiver

<table>
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<tr>
<th>Distance</th>
<th>Count</th>
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<tbody>
<tr>
<td>&lt;50 ml</td>
<td>78,159</td>
</tr>
<tr>
<td>50-100 ml</td>
<td>32,968</td>
</tr>
<tr>
<td>100-150 ml</td>
<td>19,463</td>
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<tr>
<td>150-200 ml</td>
<td>426</td>
</tr>
<tr>
<td>200-250 ml</td>
<td>3</td>
</tr>
<tr>
<td>250+ ml</td>
<td>3</td>
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POSITIONS REPORTED

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<th>1/17/2020</th>
<th>1/16/2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS-B Mode-S</td>
<td>34,869</td>
<td>180,671</td>
<td>157,371</td>
<td>61,644</td>
<td>56,871</td>
<td>108,003</td>
<td>70,750</td>
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<tr>
<td>MLAT</td>
<td>411</td>
<td>2,355</td>
<td>1,592</td>
<td>1,145</td>
<td>1,154</td>
<td>2,945</td>
<td>2,439</td>
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<tr>
<td>Other</td>
<td>15,550</td>
<td>85,094</td>
<td>71,797</td>
<td>39,226</td>
<td>38,019</td>
<td>69,549</td>
<td>53,251</td>
</tr>
<tr>
<td>Total</td>
<td>50,830</td>
<td>268,120</td>
<td>230,760</td>
<td>102,015</td>
<td>96,044</td>
<td>180,497</td>
<td>126,440</td>
</tr>
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</table>
SDR Sharp

SDR# (read SDR Sharp) is a simple, intuitive, small and fast PC-based DSP application for Software Defined Radio. It’s written in C# with both object design correctness and performance in mind. The main purpose is to offer a simple proof of concept application to get hands into DSP techniques.

We can use SDR Sharp:
- Analyze signals
- Decode signals
- Spot Anomalies in signals
On the right shows the simulation of the satellite passes.

We can automatically send the data collected wherever you want.

```bash
#!/bin/bash

# Update Satellite Information

grep "NOAA 15" /home/pi/weather/predict/weather.txt -A 2 >> /home/pi/weather/predict/weather.txt

grep "NOAA 18" /home/pi/weather/predict/weather.txt -A 2 >> /home/pi/weather/predict/weather.txt

grep "NOAA 19" /home/pi/weather/predict/weather.txt -A 2 >> /home/pi/weather/predict/weather.txt

grep "METEOR-M 2" /home/pi/weather/predict/weather.txt -A 2 >> /home/pi/weather/predict/weather.txt

# Remove all AT jobs

for i in `atq | awk '{print $1}'`; do atrm $i;done

# Schedule Satellite Passes:

/home/pi/weather/predict/schedule_satellite.sh "NOAA 19" 137.100E
/home/pi/weather/predict/schedule_satellite.sh "NOAA 18" 137.0125
/home/pi/weather/predict/schedule_satellite.sh "NOAA 15" 137.6206
```
Future Work

In the Future we plan on creating supercomputers to handle bigger infrastructures to be used commercially.
References


If you have any more difficulties, just visit the websites underlined below. They will help you with your project. Otherwise, use your favorite search engine!


3. “User Support.” Gqrx SDR, gqrx.dk/user-support

4. https://www.youtube.com/watch?v=1pr319FvOwl&t=303s


6. https://www.youtube.com/watch?v=AoXo0J6ZjIM


Acknowledgment

- University of the District of Columbia SEAS
- University of the District of Columbia STEM Center
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