Adaptive Antenna Array Processing
for GPS Receivers

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Statement of Originality

This work contains no material which has been accepted for the award of any other
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Abstract

This thesis describes a blind beamforming technique for GPS receivers. It improves the performance of a GPS receiver by mitigating interference and enhancing GPS signals separately and has a three-stage structure.

The technique is based on a linear antenna array and integrates the eigen-decomposition based subspace and multiple independent beamforming techniques. A signal model is carefully constructed. Particular emphasis is placed upon the projection matrix derived from the subspace technique. The effect of interference and phase error on this technique is discussed.

This technique is tested and compared to null steering and MMSE technique using simulated data for a number of interference environments. Furthermore, the proposed technique is applied to real data and shows several advantages over simple null steering.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADC</td>
<td>Analog-to-Digital Converter</td>
</tr>
<tr>
<td>AG</td>
<td>Array Gain</td>
</tr>
<tr>
<td>AGC</td>
<td>Automatic Gain Control</td>
</tr>
<tr>
<td>AIC</td>
<td>A Information Criterion</td>
</tr>
<tr>
<td>AM</td>
<td>Amplitude Modulation</td>
</tr>
<tr>
<td>BF</td>
<td>Beamformer</td>
</tr>
<tr>
<td>BPSK</td>
<td>Binary Phase Shift Keying</td>
</tr>
<tr>
<td>C/A</td>
<td>Course/Acquisition Code, One Type of PRN Codes</td>
</tr>
<tr>
<td>CB</td>
<td>Citizens Band</td>
</tr>
<tr>
<td>CBF</td>
<td>Conventional Beamformer</td>
</tr>
<tr>
<td>CDMA</td>
<td>Code Division Multiple Access</td>
</tr>
<tr>
<td>C/No</td>
<td>Carrier-to-Noise ratio</td>
</tr>
<tr>
<td>CW</td>
<td>Continuous Wave</td>
</tr>
<tr>
<td>DOA</td>
<td>Direction of Arrival</td>
</tr>
<tr>
<td>DS-CDMA</td>
<td>Direct Sequence Code Division Multiple Access</td>
</tr>
<tr>
<td>DS-SS</td>
<td>Direct Sequence-Spread Spectrum</td>
</tr>
<tr>
<td>FM</td>
<td>Frequency Modulation</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field Programmable Gates Array</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GRET</td>
<td>GPS RF Environment Testbed</td>
</tr>
<tr>
<td>I</td>
<td>In-phase</td>
</tr>
<tr>
<td>IF</td>
<td>Intermediate Frequency</td>
</tr>
<tr>
<td>LMS</td>
<td>Least Mean Square</td>
</tr>
<tr>
<td>LPF</td>
<td>Low Pass Filter</td>
</tr>
<tr>
<td>L1</td>
<td>L1 Frequency Band, 1575.42MHz</td>
</tr>
<tr>
<td>L2</td>
<td>L2 Frequency Band, 227.6MHz</td>
</tr>
<tr>
<td>MaxSINR</td>
<td>Maximum Signal-to-Interference and Noise Ratio</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>MaxSNR</td>
<td>Maximum Signal-to-Noise Ratio</td>
</tr>
<tr>
<td>MDL</td>
<td>Minimum Description Length</td>
</tr>
<tr>
<td>MMSE</td>
<td>Minimum Mean Square Error</td>
</tr>
<tr>
<td>MSC</td>
<td>Multiple Sidelobe Canceller</td>
</tr>
<tr>
<td>MSNNR</td>
<td>Maximum Signal-plus-Noise-to-Noise Ratio</td>
</tr>
<tr>
<td>MVDR</td>
<td>Minimum Variance Distortionless Response</td>
</tr>
<tr>
<td>NCO</td>
<td>Numerically Controlled Oscillator</td>
</tr>
<tr>
<td>PRN</td>
<td>Pseudo Random Noise</td>
</tr>
<tr>
<td>P[Y]</td>
<td>P code, One Type of PRN Codes</td>
</tr>
<tr>
<td>Q</td>
<td>Quadra-phase</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RFI</td>
<td>RF Interference</td>
</tr>
<tr>
<td>RHCP</td>
<td>Right Hand Side Circularly Polarisation</td>
</tr>
<tr>
<td>SINR</td>
<td>Signal-to-Interference and Noise Ratio</td>
</tr>
<tr>
<td>SIR</td>
<td>Signal-to-Interference Ratio</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-Noise Ratio</td>
</tr>
<tr>
<td>SV</td>
<td>Space Vehicle</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<tr>
<td>UWB</td>
<td>Ultra-wideband</td>
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