POLITECNICO DI TORINO
Repository ISTITUZIONALE

Software Defined Radio system for GNSS-Refectometry: activities performed at the Politecnico of Turin (Italy)

Software Defined Radio system for GNSS-Refectometry: activities performed at the Politecnico of Turin (Italy)

Dr. Manuela Cucca(1), Dr. Riccardo Notarpietro(1), Dr. Tommaso Panicciari(1), Dr. Salvatore Patti(1), Dr. Fabio Dovis(1), Dr. Marco Pini(2), Dr. Gianluca Falco(2)

(1) Politecnico di Torino, Electronics Depart., Corso Duca degli Abruzzi 24, 10129 Torino, Italy
(2) NAVSas, Istituto Superiore Mario Boella, Via Pier Carlo Boggio 61,10138 Torino, Italy

The GNSS signals are an important active source for Earth's remote sensing in L band. Experiments performed over sea and land surfaces demonstrated the capability of GNSS-Reflected signals (GNSS-R) for remote sensing purposes. Presently, many research groups are focusing their efforts in developing GNSS-R sensors for soil moisture, sea, sea-ice, and snow cover monitoring. Applications like drought monitoring, farm production, irrigation planning, flood protection, fire prevention, and meteorological forecasts can take advantage from retrieved soil moisture content. Detected sea-surface winds could help to identify adverse meteorological conditions far from coastal zones. Sea altimetry measurements could be used to monitor tides and to identify natural hazards (i.e. tsunamis). Sea-ice topographic changes in the Arctic and Antarctic regions and dry ice stratification could be monitored in order to improve polar climatology knowledge.

Recently the **Remote Sensing Group of Politecnico of Turin** and **NavSAS laboratory of ISMB (Istituto Superiore Mario Boella)** starts the design and implementation of a fully reconfigurable GNSS-R instrument for research activities, following a Software Defined Radio approach. Using this solution, the hardware is reduced to the RF stages only (i.e. antennas, demodulation, sampling) and the processing starts from the IF (Intermediate Frequency) samples of the raw signal. This is a low-cost portable observing system, designed to be easily placed for example also on board small aircrafts (also unmanned). In this sense, the system components were carefully chosen to minimize size and weight of the complete observing system.

Together with the system definition, a user interface is started to be developed. Actually the interface allows a quasi real time control of the received signal. The correct estimation of the whole correlation function profile (in range and frequency space) is achieved by keeping the noise level as low as possible and increasing the SNR. Therefore, it is important to optimally process signals even when long - non coherent integration time is necessary. The interface we developed is able to process such signals using FFT (Fast Fourier Transform) based acquisition algorithms. In addition, an optimized procedure is implemented to compensate for a residual code delay, enhancing the detection of weak signals. The interface allows also experimental activities planning, since it shows specular reflection points and isorange lines (inside receiver antenna's footprint), computed knowing estimated or predicted satellite positions. All the information are georeferenced using UTM (Universal Transverse Mercator) coordinate system and projected on Google© static maps. Thus, this user friendly interface is a helpful tool able to generate all the necessary output for the geophysical applications performed exploiting GNSS-R signals.

In order to test instrument and interface, some experimental activities were recently done by placing the instrument on a high cliff to collect some looks from the sea surface and on board an aircraft to collects measurements from soil reflections (rice fields water flooding, soil moisture, altimetry).

Another important activity is to adapt our GNSS-R system for space-based measurements in the framework of an educational project which is being carried out by students belonging to the Aerospace and ICT Engineering faculties of Politecnico of Turin. This student project is going to be developed in the framework of an initiative offered by the Education Office of the European Space Agency. We are trying to design and develop on a system level a space-based test bed for an Earth's Remote Sensing payload to be placed on-board a small Cubesat. This is the P-GRESSION payload (Payload for GNSS REmote Sensing and Signal detectION). It will try to demonstrate the feasibility of existing applications based on observations normally carried out by costly and operative space receivers. Two concepts will be tested. The first one is a twofold GNSS Remote Sensing experiment: 1) the GNSS Radio Occultation experiment, for the profiling of atmospheric refractivity, temperature, water vapour and electron density, which are very important for climate and meteorological purposes, and 2) The GNSS-R experiment for the land and sea surface parameters sensing. It is worth noting that, for both these GNSS-based experiments, global world coverage of observations is assured in all weather conditions. Finally, the current development/improvement of future global GNSS systems will enlarge the number of offered GNSS signals, improving consequently the resolution in time and space of the remote sensing observables.

The second concept is based on signal identification. In particular P-GRESSION will acquire signals coming from ground-based radars, in C and/or X frequency bands, both for detection and for calibration purposes. All the experiments will be based on the same Software Defined Radio approach, since after standard radio acquisition with low cost front ends and antennas, all operations will be performed by software.