Automation of Satellite Tracking for Worldwide Ground Stations

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Abstract — **Ground Station of National Centre of Spatial Technologies is a complex system that can automatic control, RF receive and track space satellites from different places on Earth. GS consists of a server side software that predicts satellite appearing at different ground stations geographically spread, schedules the tracking of the satellites and commands them to receive RF data. The client side is a rotor connected to a PC, that can track satellites on two axis, azimuth and elevation, and a RF front-end transceiver with two simplex receive ports and two half-duplex ports. The purpose of this system is providing a worldwide access via multiple ground stations to satellites, that means excluding blind spots in RF receiving.**

Keywords — **Satellite, cubesat, ground station, tracking, decode, rotor, antenna**

I. Introduction

The first artificial satellite was put in the space on October 4, 1957 by the Russians. It was named Sputnik 1, and spent 92 days in Earth orbit. Since then man has launched thousands of rockets, and put thousands of satellites in orbit. There are more than 8000 objects in orbit now, including operational, non-operational, rocket bodies, and debris. They are orbiting at an altitude from 150, up to several thousands kilometers. Having one ground station means having contact with your satellite only couple of times during the day. On LEO orbit, the time window when the satellite appears is ten minutes or less, but every minute is precious. GS provides access to Cubesats in less then 30 minutes, by accessing different ground stations in different countries and continents.

II. Satellite Pass Prediction

Due to predictable conditions of satellite movement in space computer software can calculate a satellite's position for given moment. Calculations are done based on known orbit parameters determined at epoch. Known orbital parameters like inclination, eccentricity, argument of perigee, mean motion (revolutions per day), let us track satellite for a reasonable period of time after epoch. Orbital data for each object is grouped, and distributed as a Two Line Element (TLE) file.

To keep tracking software working precisely, one should update elements periodically. For low orbiting objects (altitude less than 500 km) TLE data should be updated every few days. For higher orbits, you can update your TLE every few weeks. Other important things include making predictions as close to real time as possible by using time synchronization, and the precise coordinates of ground station location.

III. System Components

Ground station consist of RF side and tracking side. On tracking side we have a rotor that can move on 2 axis, and a custom developed driver for rotor motors with IMU module on rotor. The inertial measurement unit is used for calibrating the position of antenna hooked on rotor. The antennas need to be pointed to north and parallel with horizon. The calibrating is performed before every satellite pass. The RF side consists of a stack of two by two cross-polarized Yagi antennas on 2m and 70 cm, connected each lite to LNA's. The receiver is a SDR front-end device called USRP B200 connected to a PC via USB.

Server side is based on Ubuntu Server 14.04. All data about satellites, radio frequency's on satellites transponders, modulation types is staked in a Sqlite database. All scripting and executing is done by python and bash scripts. The web interface, from which we can access all the schedules, received RF data, decoded data and add a observation to a satellite is based on HTML and Django framework. For decoding data from weather satellites such as NOAA, it is used a console version of wxtoimg decoding software, that provides more the 15 images processed from received RF data.

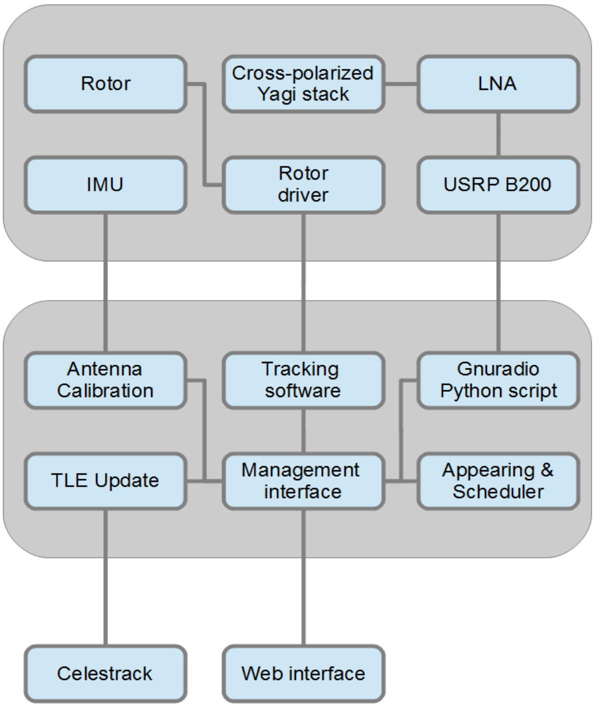

Fig. 1. Overall architecture of the ground station system.

IV. WEATHER SATELLITES PROCESSING

NOAA APT transmissions are analog transmissions. The data coming from the imaging sensors is used to amplitude modulate a 2.4 kHz sub-carrier, which is then used to FM modulate the VHF carrier at 137.x MHz.

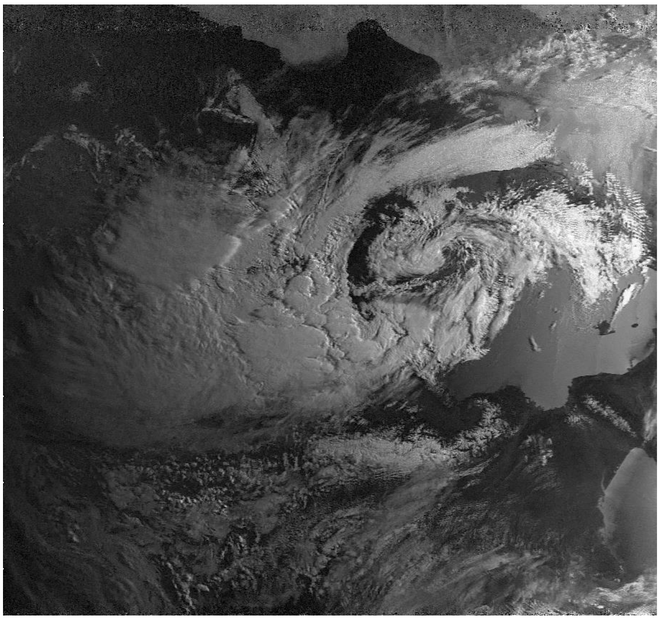

Fig. 2. Contrast image received from NOAA18 satellite.

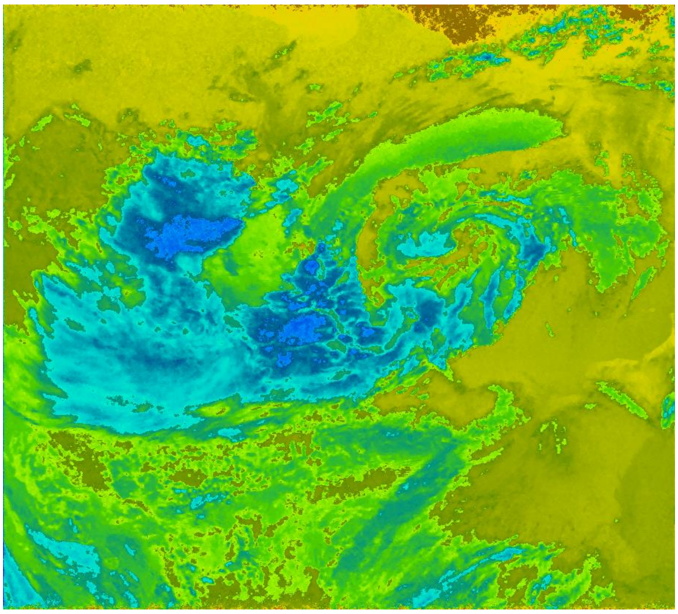

Fig. 3. Thermal image received from NOAA18 satellite.

ACKNOWLEDGMENT

Author would like to thank Sergiu Candraman for valuable guidance and advice during concept testing.

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