

Advanced Navigation Research Lab for Universities!!!

Abstract

Universities play a vital role in research and innovation. Academic researches provide high quality journal articles, technically designed conference proceedings and many more. But it can also have a high impact in the government, industry and public sector when utilized effectively. This has been proven time and again with various academic research leading to world class innovations and benefit to mankind. Once such field where universities can contribute immensely is the field of navigation. One of the major contributors in recent time is the satellite navigation namely the GNSS – Global Navigation Satellite Systems. The need of GNSS research, benefits to university, pre-requisites for navigation lab is detailed in this article.

Contents

Introduction	3
GNSS Research Opportunities	4
Mapping to university projects	5
Benefits to universities	5
SIMAC2 - Accord's Indigenous Low cost, Portable GNSS Simulator	6
Reference	8
About the Author	8
About Accord Software & Systems	9

Introduction

Research is one of the main focuses of any university. Most of the universities consider advanced research as a critical part of their university mission and focus strongly in achieving the mission. Universities invest a lot of technical, monetary and human resource on all aspects of research. This results in innovation and discoveries that lead to improved lifestyle. This has led to transforming the existing world into a better place in all walks of life including medical, engineering, agriculture to name a few.

One such research area is the field of navigation technologies which has immensely gained momentum with passing years. From Stone Age, navigation has always been in its ascending path starting with landmark based navigation that followed marks using stones, trees, monuments, etc. However these were limited in its local usage. With new discoveries and inventions in celestial techniques, navigation was improved with the aid of sun, moon and stars orbit tracing. But with the involved complexity of the system and degraded performance based on place and time, it was not possible to accept it globally. Further, with the introduction of dead reckoning technologies such as gyroscope, accelerometer, compass, odometer, navigation became easier and quite popular. However, constant demand from user community for better performance still prevailed. With the advent of satellite systems, several closed doors of improved navigation opened up providing ample research opportunities for researchers and scholars.

Global Navigation Satellite Systems (GNSS) is one

such satellite based radio navigation system capable of providing navigation data to users on or near the surface of the Earth any-time, any-where and under any-weather conditions. Due to its code division multiple access (CDMA) technique, it provides sufficient immunity from intentional/un-intentional jamming. With its design and modularity, these systems can provide low cost, high accuracy standalone navigation, without any aiding, to a great extent.



GNSS comprises of navigation satellite systems from various pioneers including Global Positioning System (GPS) of the US, GLONASS of Russia, GALILEO of Europe, BEIDOU of China and Indian Regional Navigation Satellite System (IRNSS) of India ^[1, 2]. With the advent of emerging GNSS systems, researchers worldwide are extensively working in improving system integrity, reliability, and efficiency. Towards this, universities around the

globe like the Department of Geomatics Engineering at the University of Calgary, Canada ^[3], the GPS Lab at Stanford University, California ^[4], the GPS Laboratory in Cornell University, New York ^[5], the SNAP lab at the University of New South Wales,

Sydney ^[6], the GNSS Laboratory at the University of Burdwan, India ^[7], CSIR-National GeoPhysical Research Institute, Hyderabad ^[8] among many others, are deeply involved in GNSS.

GNSS Research Opportunities

A summary of the major research opportunities available for universities is provided below:

- ▲ Research in the area of GNSS receiver design
 - Design, development and testing of GNSS software defined radios
 - Algorithm development applied to static, kinematic, Precise point positioning for high precision applications
 - Guidance, marine, airborne and space weather applications
 - Advanced algorithms for challenging environments like indoors, urban canyon, forest areas, ships, mountains and so on
 - Improving performance of receiver in the presence of interference
 - High precision and accurate algorithms for timing solutions using GNSS
- ▲ Research in signal error modelling
 - Satellite-based errors including orbit/clock errors, group delay modeling for multi-frequency modes.
 - Propagation errors like Ionosphere/Troposphere, Multipath and Interference
 - Receiver-based errors like antenna induced errors, Receiver clock/Noise modelling.
- ▲ Research in GNSS integration with aiding systems
 - SBAS (GAGAN, EGNOS, MSAS, SDCM)– Improve system integrity using augmentation satellites
 - DGNSS – Improve position accuracy significantly using aiding from reference station receivers in differential mode of operation
 - INS - fusion with GNSS using low to high performance sensors for high dynamics application, Attitude determination, terrestrial and aerial mapping systems
 - Wireless location using GNSS Pseudolite, ultra-wideband ranging, self-contained sensors, and other signals of opportunity
 - GSM, Wi-Fi, Bluetooth integration for mobile applications

Mapping to university projects

With the abundance of research possible in the field of GNSS, several researchers and students will have the opportunity to explore new ideas and develop creative techniques that can aid the industry for improving the system performance. Some of the university projects that can be mapped to GNSS research are provided below.

- ▲ Civil Engineering - Using GNSS in Surveying and Mapping activities
- ▲ Earth Science - Environmental monitoring for Ionosphere and Troposphere models

Benefits to universities

The one question that always arises whenever universities need to explore new arena is the benefit for its students and its organization. GNSS domain has already paved way to significant research in several universities which is witnessed in the form of conference papers, journal articles, student papers in Institute of Navigation^[9], world's largest technical meeting and showcase of GNSS technology, products and services. Some of the highlights of university benefits are provided below:

- ▲ Involvement in cutting edge GNSS technology
- ▲ Industry exposure for graduating students and for seamless transition from university to industry
- ▲ University brochure appraisal with highlights of state-of-the-art technology in the field of navigation
- ▲ Numerous research opportunities contributing

- ▲ Electrical Engineering – Interference studies for jamming and spoofing signals using GNSS
- ▲ Computer Science – Real time and embedded solutions design for software defined radios
- ▲ Electronics - Position and navigation, ground-based systems and augmentation systems integration
- ▲ Mathematics – Error modelling algorithms (atmospheric, antenna patterns, statistical multipath modelling, user dynamics models)

to technical articles, journals, thesis report

- ▲ Creating excellent engineers capable of bridging the gap between research and industry

To take utmost advantage of the GNSS research field, every university needs to have a research lab minimally equipped with the following:

- ▲ **Satellite System** – GNSS Simulator to mimic live scenarios or live antenna or create user defined scenarios.
- ▲ **Multi-Sensor System integrators** – GNSS Receivers, IMU Sensors, Dead Reckoning sensors, GNSS clock units, Pseudolite systems
- ▲ **Interference Sources** – Signal generators
- ▲ **Testing aids** – spectrum analysers, vector signal analysers, oscilloscopes, field trial vans, data collection system, processing tools, software defined radios to name a few.

SIMAC2- Accord's Indigenous Low cost, Portable GNSS Simulator

In pursuit of the above, Accord has been developing state-of-the-art low cost, portable GNSS signal simulator. SIMAC2 can generate RF signals for GPS, GLONASS, GALILEO, BEIDOU, QZSS and various SBAS (all in L1 band including WAAS, EGNOS, MSAS and GAGAN signals) and IRNSS (Standard Positioning Service (SPS) in L5/S band). It has a user friendly graphical front end through which

user can easily configure and track the status of a simulation. The GNSS simulator is capable of simulating all the available GNSS satellites as per user selection, introduces signal anomalies like satellite orbit and clock errors, environment models for ionosphere and troposphere, different antenna models, receiver clock errors along with multipath and signal interference effects.

Following are some of the highlight features of Accord's GNSS Simulator:

- ▲ Low cost, portable simulator
- ▲ Configurable dual frequency IRNSS and GNSS L1 simulator
- ▲ 10 Hz simulation capability
- ▲ Dynamics simulation via ASCII file input or
- ▲ Waypoint navigation
- ▲ Error modelling for receiver autonomous integrity monitoring (RAIM) tests including Ramp/Step/Doppler offsets
- ▲ Multiple signal impairments include Ionosphere, Troposphere, Multipath modelling

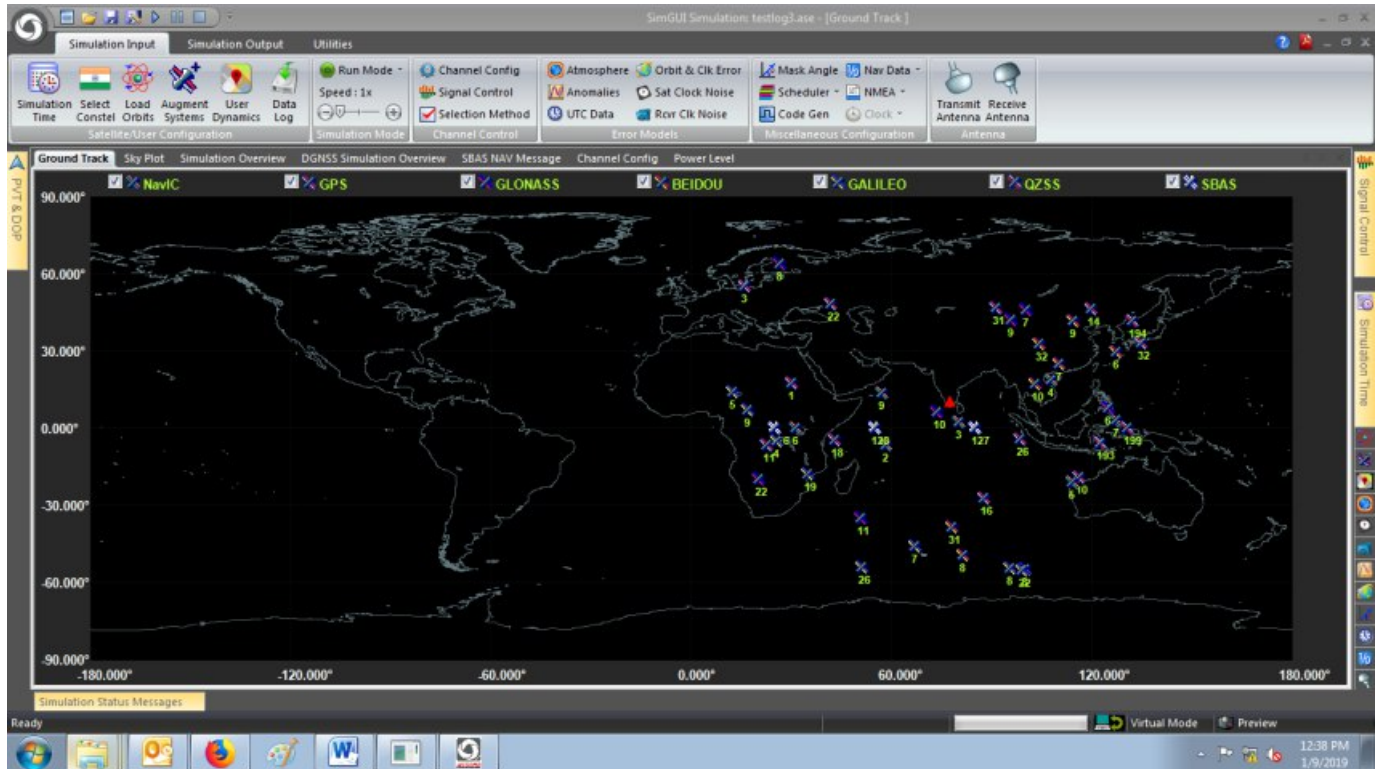
A sample overview of Accord's GNSS simulator graphical user interface (GUI) is shown in figure below. All the features are provided in a user-friendly manner for easy access in the form of ribbons and tabs. Dockable panes are provided for quick retrieval of frequently used windows in the



right-hand side of the view (like Signal Control, Simulation time panes). Recently, Accord GNSS simulators have been installed and used in couple of universities in India. IIT, Kharagpur uses Accord's GPS-IRNSS simulator to extensively simulate GPS and IRNSS signals needed for academic teaching

and research. IIT, Delhi is using SIMAC2 simulator for study of GNSS L1 signals in dynamics environment. Similarly, with the aid of GNSS simulator and other navigation tools, universities can concentrate on research areas such as GNSS signal study, receiver performance analysis in varied

environments, Research and Development in advanced algorithms for positioning, multipath mitigation, interference mitigation, innovation in the field of improved accuracy, sustained reliability algorithms.



References

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- [5] <https://gps.ece.cornell.edu/>
- [6] <http://www.snap.unsw.edu.au/>
- [7] <https://bugnss.webs.com/>
- [8] <http://www.ngri.org.in/research/gps--and-geodesy.php>
- [9] <https://www.ion.org/gnss/>

About the Author

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About Accord Software & Systems

Accord Software & Systems designs and manufactures innovative solutions to help customers maintain a competitive advantage in their markets and achieve their business goals. We provide cutting-edge Positioning, Navigation and Timing products and solutions to industry leaders in the Defence, Commercial and Semiconductors Business areas.

Accord has developed a vertically integrated GPS/GNSS portfolio consisting of Semiconductor ICs, Modules and solutions that cater to a variety of applications like Avionics, Automotive, Industrial, IoT, Marine, Telecommunications.

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