MULTI-CNSS ACTIVITIES IN THAILAND

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Sanya Klongnaivai, Infinite Sora Techonology, Co., Ltd.
TIMELINE

2012 – Join MGA
  • Technology Transfer

2013 – Multi-GNSS Asia Joint Experiment
  • Vehicle Monitoring Application

2015 – develop the low cost system
  • Vehicle Monitoring System

2017 – Product developments business start-up
  • IoT
JOINING MULTI-GNSS ASIA
DEVELOPMENT OF DRIVER BEHAVIOR MEASUREMENT METHOD FOR LEVEL OF SAFETY ESTIMATION FROM HIGH PRECISION AND HIGH RESOLUTION GLOBAL POSITIONING SYSTEM WITH QUASI-ZENITH SATELLITE SYSTEM (QZSS)
OBJECTIVES

- Algorithm for on-line driving maneuver and severity rating.
- Performance assessment of the algorithm comparison between the Conventional GPS and the enchanted QZSS.
SAFE VEHICLE BEHAVIOR

- Safe Vehicle Maneuver
  - Aggressive Acceleration
  - Hard Brake
  - High Speed Turn
  - Fast Lane Change

- Normally, detected by
  - Gyro-meter
  - Accelerometer
LIMITATION WITH CONVENTIONAL GPS

The conventional GPS has limitations:

- 3 meter error
- 1 Hz resolutions

Consequently, it cannot determine for:

- High Speed Turn (in some case)
- Fast Lane Change
QZSS - QUASI-ZENITH SATELLITE SYSTEM
# JAVAD MULTI-GNSS RECEIVERS

## Tracking Specification

<table>
<thead>
<tr>
<th>Tracking Channels</th>
<th>DELTA -G2T</th>
<th>GPS L1/L2/L2C/L5, Galileo E1/E5A, SBAS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DELTA-G3T</td>
<td>GPS L1/L2/L2C/L5, Galileo E1/E5A, GLONASS L1/L2, SBAS</td>
</tr>
<tr>
<td></td>
<td>DELTA-G3TAJ</td>
<td>Signals Tracked</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L1/L2 C/A and P Code &amp; Carrier</td>
</tr>
</tbody>
</table>

## Performance Specifications

<table>
<thead>
<tr>
<th>Metric</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomous</td>
<td>&lt;2 m</td>
</tr>
<tr>
<td>Static, Fast Static Accuracy</td>
<td>Horizontal: 0.3 cm + 0.5 ppm * base_line_length</td>
</tr>
<tr>
<td></td>
<td>Vertical: 0.5 cm + 0.5 ppm * base_line_length</td>
</tr>
<tr>
<td>Kinematic Accuracy</td>
<td>Horizontal: 1 cm + 1 ppm * base_line_length</td>
</tr>
<tr>
<td></td>
<td>Vertical: 1.5 cm + 1.5 ppm * base_line_length</td>
</tr>
<tr>
<td>RTK (OTF) Accuracy</td>
<td>Horizontal: 1 cm + 1 ppm * base_line_length</td>
</tr>
<tr>
<td></td>
<td>Vertical: 1.5 cm + 1.5 ppm * base_line_length</td>
</tr>
<tr>
<td>DGPS Accuracy</td>
<td>&lt; 0.25 m Post Processing,</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.5 m Real Time</td>
</tr>
<tr>
<td>Cold Start</td>
<td>&lt;35 seconds</td>
</tr>
<tr>
<td>Warm Start</td>
<td>&lt;5 seconds</td>
</tr>
<tr>
<td>Reacquisition</td>
<td>&lt;1 second</td>
</tr>
</tbody>
</table>

Max Resolution 100Hz
JAVAD MULTI-GNSS RECEIVER
CONCLUSIONS

- The Joint Experiment start from Nov, 2012 in Thailand
- The results will confirm the proposed applications
- We will delight to further investigation to confirm the in Asia Pacific Region with corroboration with local institute.
CONTENTS

2012-2015 (NECTEC-JAXA)


STUDY OF DRIVER BEHAVIOR DETECTION ON VEHICLE WITH SATELLITE NAVIGATION SYSTEM
In road accident, there usually are three main mistakes which are man, vehicle or road combine together. Missing a link the accident would become incident.

The person or driver is important key to avoid an accident so that the monitoring system will play important role.
# Driver’s Behavior

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<th>Physical Parameter</th>
</tr>
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<tbody>
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## LIMITATION WITH GPS

<table>
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<tr>
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<th>Current 1-Hz conventional GPS receiver</th>
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<tbody>
<tr>
<td><strong>Longitudinal Acceleration</strong></td>
<td>enough accuracy and update rate for estimate.</td>
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<td></td>
<td>For lane change, cannot estimate, not enough accuracy and update rate.</td>
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</table>
ก. ข้อมูลจาก GNSS ปัจจุบัน

ข. ข้อมูลจาก GNSS 1 วินาที
ค. ข้อมูลจาก GNSS 100 มิลลิวินาที

ง. ข้อมูลจาก PPP GNSS
OBJECTIVES

- To Evaluate the Multi-GNSS Technology for Vehicle’s Lateral Acceleration Estimation

- Scopes
  - 10-Hz Resolution
  - To Compare the Output with Single Solutions and RTK Solutions
Compare the Multi-GNSS estimate lateral acceleration with Inertia Measurement Unit
TEST VEHICLE
<table>
<thead>
<tr>
<th>JAVAD DELTA-G3T</th>
<th>FW: TRE-G3TH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal Tracked</strong></td>
<td><strong>Dual-Frequency, Carrier Phase</strong></td>
</tr>
<tr>
<td>GPS: C/A, P1, P2, L2C, L5</td>
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<tr>
<td>SBAS:</td>
<td></td>
</tr>
<tr>
<td><strong>Raw Data Recording</strong></td>
<td>1 second/point</td>
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</tbody>
</table>
LANE CHANGING CLIP

http://youtu.be/kwXfIBxs69A
LANE CHANGING TEST
With series of tests, the peak point from estimation and IMU were compared. The RTK Solution was necessary for estimating the lateral acceleration in lane change behavior because the small lateral displacement change.
TURNING TEST CLIP

http://youtu.be/PgaUap4KjFc
With series of tests, the peak point from estimation and IMU were compared. There were insignificant differences in results between Single and RTK solutions because the maneuver was larger than an accuracy limit of Single solution.
CONCLUSIONS

Conclusion

- The precision from Multi-GNSS is the key to detect the risk incident in vehicle driver’s behavior.
  - Single solution was enough for turning analysis.
  - RTK solution was required for lane changing analysis.

Future works

- The data will re-processing in precise point positioning (PPP) technique.
- LEX correction message will be considered.
DRIVER BEHAVIOR DETECTION BASED ON PPP-GNSS TECHNOLOGY
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Automotive Symposium 2014 at bangkok motorshow
2012 TEST EQUIPMENT

Automotive Symposium 2014 at bangkok motorshow
LANE CHANGING TEST
LANE CHANGING CLIP

http://youtu.be/kwXfIBxs69A
RTK SOLUTIONS

- The precision from Multi-GNSS is the key to detect the risk incident in vehicle driver’s behavior.
  - Single solution was enough for turning analysis.
  - RTK solution was required for lane changing analysis.

- Accuracy from RTK solution was less than actual lateral motion from lane changing.
  - Sub-meter class with high update rate capable for it.
  - PPP was considered
# Improvements with PPP

<table>
<thead>
<tr>
<th>Setting</th>
<th>SGS</th>
<th>PPP</th>
</tr>
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<tbody>
<tr>
<td>Positioning Mode</td>
<td>Single</td>
<td>PPP Kinematic</td>
</tr>
<tr>
<td>Frequencies/Filter Type</td>
<td>L1/Forward</td>
<td>L1/Forward</td>
</tr>
<tr>
<td>Elevations Mask</td>
<td>5°</td>
<td>5°</td>
</tr>
<tr>
<td>Ionosphere Correction</td>
<td>Broadcast</td>
<td>Iono-Free LC</td>
</tr>
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<td>Saastamoinen</td>
<td>Estimate ZTD</td>
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Automotive Symposium 2014 at Bangkok Motorshow
IMPROVEMENTS WITH PPP DYNAMIC
LATERAL ACCELERATION FROM PPP SOLUTIONS

G-SPASE, Feb 18 - 19, 2013
- PPP solutions the lane change maneuver can be detected
  - Detected all vehicle maneuver
- Sub-meter class GNSS receiver should be evaluated.
  - L1-SAIF
  - U-blox Multi GNSS
  - LEX
DRIVER BEHAVIOR DETECTION BASED ON MULTI GNSS TECHNOLOGY
The most important parts is driver.
IN-VEHICLE DATA LOGGER
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PREVIOUS WORK
## Improvements with PPP

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</table>
Start

Number of satellite is more than 6

No

There is the changing of heading > 0.06 degree

Yes

Neglect

No

The maximum of heading angle changing compare with the minimum heading angle > 1 degree

Yes

Neglect

No

The different of heading angle between 1st heading and the last heading angle > 10 degree

Yes

Neglect

No

Lane changing

Yes

Turning

Show the number and order of driving behavior case

Stop
TESTED ROUTE
- Real
  - Review the video footage (V-box)

- SGS – single solution
  - Conventional GPS
  - With 10-Hz update rate

- PPP – precise point positioning
  - Dual frequencies, ionospheric correction
  - With 10-Hz update rate
<table>
<thead>
<tr>
<th></th>
<th>Total Events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lane Change, PPP</td>
</tr>
<tr>
<td>Detection</td>
<td>50%</td>
</tr>
<tr>
<td>Fault</td>
<td>33%</td>
</tr>
</tbody>
</table>
The advance multi-GNSS precise point navigation solution was investigated under driving behavior detection algorithm.

The PPP navigation output combine with algorithm can improve:
- Lane-change from nothing to half of total incidents.
- Turning same as SGS.

There still fault detection that needs to further investigated.

CONCLUSIONS
- This work had tested with a ten-thousand dollars receivers with decimeter accuracy.
- To feasible in real application, sub-meter accuracy, hundred dollars will further investigate.
DRIVER BEHAVIOR DETECTION BASED ON MULTI-GNSS PRECISE POINT POSITIONING TECHNOLOGY
OBJECTIVES

- To improve a simple vehicle maneuver detection algorithm is investigated.
  - Multi-GNSS with precise point positioning (PPP)

- Furthermore, the PPP in this study consisting of 2 method,
  - (1) Dual Frequencies estimation
  - (2) QZSS broadcast.
EXPERIMENTAL & RESULTS
DETECTION ALGORITHM
GNSS PROCESSING

PPP VS PPP L1

- PPP
  - Survey class receiver
    - Dual frequencies ionosphere correction
    - Precision ~0.2m
    - $15,000

- PPP-L1
  - Sub-meter class receiver
    - Broadcast Ionosphere correction from QZSS
    - Precision ~0.6m
    - $400 (prototype)
- Visual: V-box Pro
- GNSS: JAVAD G3T
  - Post Processing with RTKlib
    - Single Solution
    - PPP
    - PPP L1
- Vehicle: ISUZU Dmax V-cross 4Dr
RESULTS

<table>
<thead>
<tr>
<th></th>
<th>RL</th>
<th>PPP</th>
<th>PPP L1</th>
<th>SGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>34</td>
</tr>
<tr>
<td>Error</td>
<td>43%</td>
<td>43%</td>
<td>386%</td>
<td></td>
</tr>
</tbody>
</table>
Both PPP on Multi-GNSS techniques can improve the detection performance in lateral motion detection.

- 386% overestimate form conventional GPS positioning technique.
- 43% overestimate in PPP and PPP-L1 techniques
- 9 times improvements

PPP-L1 indicated that low cost sub-meter class might apply to vehicle detection.
DEVELOP THE LOW COST SYSTEM

For commercialization
PRODUCT PICTURES

Multi-GNSS receiver
DATA CAPTURE W MULTI-GNSS RECEIVERS

Ublox M8030 Multi-GNSS (GPS+BDS+QZSS) (GPS+GLO+QZSS)
Setting for Automotive filter output
Raw satellite measurement

High Frequency Datalogger
5-Hz update rate (positioning and raw)
RTK PROCESSING

- Post Processing with RTKlib
RESULTS
UBLOX(AUTOMOTIVE) VS RTK(L1)
CURRENT SITUATIONS

- We have developed the application for Sub-meter accuracy.
- Local correction / augmentation via internet connection.
- Public augmentation will be the keys to compete with Japan’s QZSS system.
  - QZSS have tested feasibility on sub-meter satellite augmentation in 2015
- Positioning and Signal Band of BDS are advantages over Thai’s sky.
  - Lower cost on antenna
  - Urban canyon
EXISTING OF U-BLOX®
HIGH RESOLUTION RECEIVERS
5Hz resolution
meter trajectory accuracy
DETECTION METHODOLOGY

GNSS Receiver

Time

Heading

Speed

Yaw Rate

Lateral Acceleration ($g_{lat}$)

$g_{lat} > 0.25g$ or $g_{lat} <= -0.25g$

Incident Count: Rapid Turning Fast Lane Change

Longitudinal Acceleration ($g_{long}$)

$g_{long} > 0.25g$ or $g_{long} <= -0.25g$

Incident Count: Rapid Acceleration Sudden Brake

Data Preception

Calculation

Incident Count

Determination
PATTERN ANALYSIS

Rapid turning with double curvature

Rapid turning with single curvature

Fast lane change

Braking
Test Track

- FAST LANE CHANGE 1
- FAST LANE CHANGE 2
- START AND FINISH
- TURNING 1
- TURNING 2
- Rapid Acceleration
- Sudden Brake
- 70 metres
- 850 metres
SELECTED TEST CLIP
SELECTED TEST CLIP
RESULTS AND DISCUSSION

Detection of excessive lateral acceleration

Detection of excessive longitudinal acceleration
PRODUCT DEVELOPMENTS
BUSINESS START-UP
Blue - blox
Green - Normal GPS receivers

Resolutions
OTHER ACTIVITIES
Guest Speech
Mr. Hajime Onga
First Secretary for Policy on Information & Communications Technology, on Science, Technology & Innovation
Embassy of Japan in Thailand

QZSS Utilization Workshop
In Thailand

January 22nd, 2016
Friday
at
Chulalongkorn University
Faculty of Engineering

10:00AM : Opening Address & Keynote speech Thai / Japan Presentations: Introduction / disasters prevention
12:00AM : Lunch
Presentations: ITS / MAPs / Positioning / Technical / Probe
5:00PM : Closing Address
5:30PM : Reception Dinner
SPACE   EDUCATION
Gnss Applications

- LBS (Location Base Services)
  - Mobile Phone
  - Pedestrian Navigation
  - Short Message
  - Sightseeing
- Other
  - Ionospheric Observation
- Precise Positioning
- Disaster Mitigation
  - Tsunami Monitoring
  - Land Slide Monitoring
  - GNSS Meteorology
  - Emergency Message
- ITS
  - Probe CAR
  - Mobile Mapping
  - Road Pricing
  - CAR Navigation
- Precise Agriculture
- Construction Machine
- Guidance /Control
Multi-GNSS 101.02 (Multi-Global Navigation Satellite System)

หากต้องการใช้งานระบบ Multi-GNSS ต้องทำอย่างไร?

ในปีที่ล่าสุดท่านพยายามทำความเข้าใจถึงการทำงานของยุคยุคกันนั้นก่อนที่จะเริ่มต้นใช้งาน ทะลุระดับ ขอให้เราฝึกฝนความสามารถในการส่งสัญญาณของสถานีวิทยุถึงแล้วกัน เมื่อเราจะรับฟังสถานีไหน ต้องเริ่มท่านใช้ (แต่ละ) เริ่มทำการรุ่น (Tune) เครื่องรับไปยังสถานีที่เราต้องการถึงจะมีความเข้าใจในรูปแบบที่มีหลายคำว่า แต่ต้องเครื่องรับให้ตรงค่ะนั้น อั้...
Infinite Sora Technology

Sanya Klongnaivai

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Co-Founder
Internet of Things Specialist

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