ADVANTAGES OF DEPLOYMENT OF BESPOKE GNSS POSITION ESTIMATION METHODS IN NAVIGATION DOMAIN BASED ON RAW GNSS PSEUDORANGES

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BESPOKE GNSS POSITION ESTIMATION METHODS BASED ON RAW PSEUDORANGES
Introduction and motivation

Rising needs for transparent and flexible GNSS-based position estimation process that suits requirements for different classes of GNSS applications

Advancements in mathematical methods, and computing algorithms, performance, and architectures

Software-Defined Radio (SDR)

Google LLC opens access to raw GNSS pseudoranges through Location API as a framework for third-party utilisation
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- GNSS positioning (position estimation) process

![Diagram showing GNSS positioning process]

- RF electrical signal
  - Radio-frequency domain
  - Digitised signals in base-band
  - Base-band processing domain
  - Navigation processing domain

- Mathematical algorithms applied on numerical pseudoranges

- Raw pseudoranges
  - Satellite clock correction
  - Ionospheric delay correction
  - Tropospheric delay correction
  - Corrected pseudoranges
What does affect the GNSS positioning accuracy?
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- Advanced GNSS SDR architectures
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- **Google Location API**
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• Proposed generalised utilisation of Google Location API on Android devices

Tailored by trusted parties for targeted applications in GNSS SDR receiver (within a smartphone)
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• Proposed generalised utilisation of Google Location API on Android devices – case of tackling effects of positioning environment.
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- Proposed generalised utilisation of Google Location API on Android devices – case of ionospheric delay correction

Klobuchar model

\[ \text{Ion}_{\text{SLANT}} = \text{Ion}_{\text{VERT}} \cdot m(\text{elev}) \]
\[ m(\text{elev}) = 1 + 16(0.53 - \text{elev}/\pi)^3 \]

**Klobuchar coefficients**

Where:
- DC = 5ns
- φ = 14 (ctt. phase offset)
- t = Local Time

\[ A = \sum_{n=0}^{3} a_n \cos n\varphi \quad P = \sum_{n=0}^{3} \beta_n \cos n\varphi \]

Being:

Amplitude

\[ \text{Dc} = 5\text{ns} \]

Time Delay (ps at 1.6 GHz)

Local Time (hours)

Ionospheric delay correction

where:

\[ \text{Ion}_{\text{VERT}} \]

\[ \varphi = \text{Geomagnetic Latitude} \]
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- Proposed generalised utilisation of Google Location API on Android devices – case of improved position estimation methodology

\[
\cos \lambda_i(s_i, s_k) = \frac{[x_i - x_k \quad y_i - y_k \quad z_i - z_k][x_i \quad y_i \quad z_i]^t}{||[x_i - x_k \quad y_i - y_k \quad z_i - z_k]|| \cdot ||[x_i \quad y_i \quad z_i]||}.
\]

\[
x_{k+1} = x_k - (J_k^t W J_k)^{-1} J_k^t W p'(x_k)
\]

\[
W_1 = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
\sin \theta(s_1, s_k) & 1 & 0 & 0 & 0 \\
0 & \sin \theta(s_2, s_k) & 1 & 0 & 0 \\
0 & 0 & \sin \theta(s_3, s_k) & 1 & 0 \\
0 & 0 & 0 & \sin \theta(s_4, s_k) & 1 \\
\end{bmatrix}
\]

\[
W_2 = \begin{bmatrix}
1 + \frac{2}{\sin \theta(s_1, s_k)} & 0 & 0 & 0 & 0 \\
0 & 1 + \frac{2}{\sin \theta(s_2, s_k)} & 0 & 0 & 0 \\
0 & 0 & 1 + \frac{2}{\sin \theta(s_3, s_k)} & 0 & 0 \\
0 & 0 & 0 & 1 + \frac{2}{\sin \theta(s_4, s_k)} & 0 \\
\end{bmatrix}
\]
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- Proposed generalised utilisation of Google Location API on Android devices – case of Positioning-as-a-Service
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• Conclusion

• Access to raw GNSS pseudoranges opens room for:
  – utilisation of improved and advanced position estimation methods in GNSS SDR receivers in Android-based devices (affects IoT, ITS, ADS-B, AIS, eCall and many other services and systems)
  – technology and business developments

• Trust in provided raw GNSS pseudorange data – for future assessment

• We continue our research segments of GNSS position estimation methods and techniques, bespoke GNSS error correction models, and Positioning-as-a-Service concept
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- **Selected references**
  - Filić, M. (2017). Analysis of the position estimation procedure based on given GNSS pseudoranges in a GNSS SDR receiver (MSc thesis, in Croatian). Faculty of Science, University of Zagreb. Available at: https://zir.nsk.hr/islandora/object/pmf%3A3230
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• **Selected references**


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- **Selected references**
THANK YOU FOR YOUR ATTENTION!

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