Measurement 118 (2018) 83–95

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Decision-making solution based multi-measurement design parameter for optimization of GPS receiver tracking channels in static and dynamic real-time positioning multipath environment

F.M. Jumaah[a,b], A.A. Zadain[a,*], B.B. Zaidan[a], A.K. Hamzah[a], R. Bahbibi[a]

[a] Department of Computing, FSKIK, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia
[b] Department of Advanced Applications and Embedded Systems, Intel Corporation, Plot 6 Bayan Lepas Technoplex, Pulau Pinang 11900, Malaysia

ARTICLE INFO

Keywords:
Multi-measurements analysis
GPS receiver design
Multi-criteria decision making
TOPSIS-AHP algorithm

ABSTRACT

This paper presents a new decision-making solution based multi-measurement design parameter for GPS baseband receiver tracking channel selection in static and dynamic real-time positioning multipath scenarios. The novelty claim is the use of evaluation design parameter matrix (EDPM) to measure and rank the overall performance of tracking channel selection. However, the major problems with the evaluation of different operation modes of the GPS receiver include finding reasonable thresholds to select the number of GPS baseband receiver tracking channels that can balance the trade-off between conflicted GPS design parameters and determining the optimum GPS baseband receiver tracking channels in terms of power consumption and localisation accuracy. A practical study that included multipath environment was performed based on static and dynamic real-time positioning. A total of nine different operating modes of GPS receiver are evaluated by each design parameter, namely power consumption, localisation accuracy and time with no position available in multipath scenarios. All the results for positioning scenarios given these parameters are gathered in one platform such as EDPM. Subsequently, the number of tracking channels was scored based on EDPM using multi-criteria decision-making techniques, such as integrated analytic hierarchy process (AHP) and technique for order performance by similarity to ideal solution (TOPSIS); these solutions are from different contexts (e.g., individual and group). The systematic ranking of the static and dynamic scenarios is presented to three experts for subjective judgment to validate the experimental results. Findings of this research in static and dynamic positioning are as follows. (1) Systematically, the integration of TOPSIS and AHP is effective for solving the conflict between GPS design parameters and determining the optimum GPS baseband receiver tracking channel problems. (2) Individual context shows variances among expert ranking. (3) Internal and external aggregations show that a group of TOPSIS are compatible, and NCRT 1 is selected as the best.

1. Introduction

The global positioning system (GPS) is a prominent system which provides accurate and precise positioning services. GPS has been widely used due to its worldwide navigation performance [1]. In designing GPS receivers, multiple parameters which might affect the performance of the receiver are as follows: power consumption of the receiver [2–7] and positioning accuracy [8–10]. Ideally, the minimum number of GPS receiver tracking channels required for user position calculation is four [2,10]. In real-time receiver operation, under a probable amount of time, the GPS receiver has less than four tracking channels. During this time, the GPS receiver has no position coordinate readings. Numerous developments of GPS have been achieved through continuous silicon technology development, embedded system design advancement and considerable amount of research efforts to achieve low power consumption with high- performance receivers [11]. In mobile devices, batteries are considered important demand in terms of power consumption (see Table 1).

High battery drain restricts the use of mobile devices, thereby degrading the functionality of the device [12]. The high power consumption of GPS receiver chips causes overheating issues and limits the GPS function continuity in mobile devices [3]. Furthermore, the high power consumption leads to a system that is either physically large (to accommodate large batteries) or has a short deployment time (due to reduced battery capacity) [13]. The continuous operation of GPS receiver consumes power, whereas turning it off for a long time degrades

* Corresponding author.
E-mail address: aws.alaa@gmail.com (A.A. Zadain).

https://doi.org/10.1016/j.measurement.2018.01.011
Received 11 July 2016; Received in revised form 6 November 2017; Accepted 8 January 2018
Available online 16 January 2018
0263-2241/© 2018 Elsevier Ltd. All rights reserved.

Table 1
Evaluation design parameter matrix.

No. tracking criteria channel	Power consumption	Localization accuracy	$T_{no\text{-}pos}$
TC 1	PCV1	LAV1	T1
TC 2	PCV 2	LAV2	T2
TC 3	PCV 3	LAV3	T3
TC 4	PCV 4	LAV4	T4
TC 5	PCV 5	LAV5	T5
TC 6	PCV 6	LAV6	T6
TC 7	PCV 7	LAV7	T7
TC 8	PCV 8	LAV8	T8
TC 9	PCV 9	LAV9	T9

PCV: Power consumption values.
LAV: Localisation accuracy values.
T: Time with no positioning.

GPS usability.

Localisation accuracy can be considered a key factor for enabling innovative applications in intelligent transportation systems. Unfortunately, current commercially available GPS devices suffer from inaccuracy to varying degrees. A standalone GPS device typically suffers from positioning error of up to tens of meters, which is significant for many safety–critical applications [9]. GPS-based localisation often lacks consistency in providing the required accuracy, which is a deficiency that many applications cannot tolerate, particularly mission-critical applications [14]. The positioning accuracy may decrease due to the error sources of GPS measurement, such as satellite clock, ephemeris-related errors, ionosphere and troposphere delays and multipath effect [15]. Among the potential sources of GPS signal degradation, multipath is the major error source that degrades accuracy and precision of GPS positioning [16–18]. All these error sources, except multipath, can be predicted and corrected by existing models and differential systems, such as the well-known differential GPS. However, the multipath errors depend on the surrounding environment of the receiver, thus leading to various GPS receivers. Hence, multipath errors are considered to be the major error sources of GPS [1,18–20]. The GPS multipath phenomenon occurs when GPS signals travel from a satellite to the receiver antenna via several paths due to reflection or diffraction of signals by nearby obstacles, such as buildings and mountains [21]. Multipath can be classified as line-of-sight (LOS) when the receiver collects the direct and the reflected signals, and non-line-of-sight (NLOS) when no direct view of the satellite is available and only the reflected signal is acquired [22].

Theoretically, increasing the number of tracking channels in the GPS baseband receiver will increase the design complexity and size. Hence, the power consumption would significantly increase [23–26]. Furthermore, additional satellites should be acquired and tracked by the receiver to improve the location accuracy of a position. Thus, an increased number of tracking channels is required in the receiver [10,27]. However, selecting the number of GPS baseband receiver tracking channels is a difficult and challenging task because each number of required tracking channels has multiple attribute parameters for evaluation. For example, power consumption and localisation accuracy have been proven to be extremely important in the setting because these parameters provide an objective complement to the decision and optimise critical factor that affects the GPS receiver outcome. Furthermore, each designer provides different weights for these attributes (GPS Quality Metrics) according to the design application requirement, either low power application with acceptable accuracy or high accuracy level application without considering power. By contrast, developers who aim to carry out an optimum GPS baseband receiver to solve this problem would probably target different attributes as the most important attribute. Thus, the optimum GPS baseband receiver tracking channel selection is a multi-complex attribute problem.

This study presents a new decision-making solution based multi-measurement design parameter for GPS baseband receiver tracking channel selection in multipath environment scenarios. A total of nine different operation modes of GPS receiver were evaluated by each design parameter, namely power consumption, localisation accuracy and time with no position available for static and dynamic positioning multipath scenarios. Then, these modes were integrated between AHP and TOPSIS methods in different contexts (e.g., individual and group) to measure and rank the overall performance of tracking channel selection. The remaining sections of this paper are organised as follows. Section 2 presents the literature review. Section 3 describes the decision-making methodology for the selection of GPS receiver tracking channels based on multi-criteria analysis. Section 4 reports the results and discussion. Section 5 concludes the paper.

2. Literature review

A typical design of GPS receiver comprises an RF Front-End module, baseband processor and embedded software [19]. The RF Front-End module receives the GPS signal from the satellites, filters the signal, shifts the GPS signal frequency down to an intermediate frequency (IF) and finally digitises it as an input to the baseband processor. The baseband processor acquires a lock status from multiple GPS satellite signals through the correlation process. The software controls the operation of the baseband processor and extracts the GPS satellite ephemeris data and the position calculation [4].

Various strategies have been studied and categorised in terms of antenna design, improved receiver internal architecture and post-processing to mitigate the multipath effect on GPS receivers [21]. Evidently, hardware- or signal-based approaches have improved the positioning accuracy to a certain extent [29]. Further improvement has been performed to take advantage of data processing schemes, which can be classified as time- and frequency-domain processing [21].

In antenna design approach, the multipath suppression depends on the antenna design of the receiver, such as the choke ring [30]. A multipath suppression antenna can reject multipath signals which impinge from a low elevation angle. However, not all multipath signals impinge from a low elevation angle in mobile platforms or indoor applications [1]. Consequently, the antenna cannot reject every multipath signal. Another method is based on modified delay lock loop (DLL), such as the narrow correlator (NC) [31]. This method is only effective in mitigating errors caused by mid-distance multipath. The other methods are signal processing methods, such as the multipath estimation DLL (MEDLL) [32,33] and the multipath mitigation technique (MMT) [34]. The parameters (delay, amplitude and phase) of multipath and direct signals are estimated for suppression in these methods. The CCF method is proposed to estimate the multipath in [35]. The combination of the DLL and the magnitude of each estimated DLL signal are used in [36]. A method using FIR filters to equalise the distortion induced by multipath signals is proposed in [37]. The virtual multipath based technique [38], which is efficient when the first multipath signal is the strongest, was proposed. An alternative algorithm for mitigating GPS multipath was presented by integrating unscented Kalman filter (UKF) and wavelet transform with particle filter in [21].

The current literature on the GPS receiver tracking channel optimisation is limited and scattered. However, a few attempts were made to create a model for either power consumption reduction or localisation accuracy improvement. The power consumption of the digital baseband receiver can be achieved by utilising several techniques, namely fast synchronisation [2], asynchronous design methodology [3], offload cloud computation [39,40] and trajectory data utilisation [41]. The GPS deployment time reduction techniques efficiently utilised energy and handled deployment time reduction of the GPS receiver. Deployment time reduction can be achieved by adaptive GPS sampling method [41], sensor-assisted GPS localisation (such as Wi-Fi, accelerometer and DGPS) [42] and duty cycle optimisation [13,2].

Significant research efforts in power-efficient GPS receiver design

Download English Version:

https://daneshyari.com/en/article/7121605

Download Persian Version:

https://daneshyari.com/article/7121605

Daneshyari.com