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作品名稱
適用於行動通訊系統下使用多輸入多輸出特徵定之粒子濾波器
Positioning Particle Filter Using MIMO Fingerprinting For Cellular Communication

隊伍名稱
我一點都不low / I am not low at all

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作品摘要

自從FCC 公布了E911 purpose 後，許多有關定位技術的研究便陸陸續續的冒出頭來，定位技術可以簡略的分為室外和室內定位，室外定位主要會著重在定位範圍，而室內定位主要是在定位準確度上，所以依照不同的需求便有不同的定位技術發展出來；現在市面上最流行的室外定位技術為GPS（Global Positioning System），也就是全球定位系統，是現在普及率和準確率最高的定位系統。但是GPS 需要在使用者端也加裝GPS 晶片組，用來接收衛星信號加以運算，所以會造成設計成本提高，而且因為屏蔽效應（Shadowing）的關係，所以在室內（indoor）以及大樓多的都市區域（urban area）的定位效果會比較差，還會受到天候狀況的影響；而室內定位大多使用的技術主要是基於RSSI（received signal strength indication），這是一種透過信號衰減程度來判斷距離的方法，不過RSSI 會面臨多重路徑（Multipath）的問題，這會對定位的精準度有所影響，而且因為信號衰減的速度太快所以也會遇到定位範圍的問題。

所以本企劃介紹了一種方法叫（Particle Filter），但是傳統particle filter 的理論在硬體的實現方面會碰到很大的瓶頸，問題來自於傳統particle filter 是採用systematic resampling 的方式。在systematic resampling 裡我們必須把每顆particle 的weight 做normalize，而做normalize 的前提是要先獲得所有particle 的weight 資訊，這在硬體實做採用sequential 的運作架構下會花費掉非常多的latency。

為了解決particle filter 在硬體實際實現的問題，我們從最根本的理論上去做改變，上面有提到particle filter 在硬體上實現的瓶頸來自於resampling 的處理，因此我們所提出了一個新的resampling 的方式可以做pipeline 的硬體設計並且不需要花費額外的latency 以及保持良好的精準度，總的來說就是綜合systematic resampling 和IMHresampling 的優點去讓我們的硬體使用更有效率。

Abstract

This work proposes a particle filter (PF) with threshold Independent Metropolis Hasting (IMH) resampling for the multiple input multiple output(MIMO) fingerprinting positioning in the cellular system. The proposed technique improves the positioning accuracy in both indoor and outdoor conditions from two perspectives. For the system perspective, the MIMO system with fingerprinting improves the transmitting diversity and positioning accuracy in the spatial channel model (TR25.996). For the digital signal processing perspective, the proposed particle filter can successfully address the non-linearity issue and combat the non-ideal effect in real channel condition.

The simulation results show that the proposed method has good positioning accuracy, about 5m RMSE when Spacing is equal to 4m. To solve the bottleneck of hardware design in the original particle filter, the thesis proposes threshold IMH resampling algorithm to replace traditional systematic resampling, which has low hardware utilization rate and long processing latency. Further, this thesis proposes selective sampling strategy to reduce the number of particle converging iterations and improve positioning accuracy.

In the hardware architecture, this thesis designs flexible particle number and sampling threshold according different channel conditions. When the channel condition is bad, we use more particles to estimate the position. On the contrary, we can use fewer particles to reduce the latency. Moreover, using proposed threshold IMH resampling in the hardware, the hardware utilization rate can increase to more than 95% according different particles. Compared to the traditional systematic resampling which needs 3M +L cycles for an iteration, the total processing latency of my design is reduced to M + L cycles, where M is particle number and L is pipeline number. Moreover, we propose to research implementing our proposed threshold IMH resampling design into PE-CU architecture for further reducing the processing latency of particle filter. The complexity of the PE-CU architecture is low due to the proposed CU resampling scheme does not need particle routing. This study uses Arm 3.2 TSMC-0.18um cell library to implement the particle filter hardware. The operating frequency of the chip is 106MHz when supply voltage is 1.8V. The core area is 1.48mm^2, and the chip area is 3.64mm^2.

This work anticipates the implemented particle filter chip is utilized in the base-station to localize mobile users. Hence, the high operating frequency is the major target we want to achieve to make Time-Division Multiple Access (TDMA) scheme practicable in our positioning system.

指導教授

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研究領域

無線通訊系統、通訊系統晶片設計、數位訊號處理晶片設計。