Sample Translation

Wireless Sensor Networks

- See below for the original Chinese manuscript.
- **A native-speaker of English who has studied this field** proofreads the translated English.
- The quality of the translated manuscript is suitable for publication in an international journal.

Prolonged audio signal observation in the design of Wireless Sensor Networks

1. Introduction

In the rapid progress and maturation of wireless communication technology, small size and mobility have been the primary design criteria for electronic products. This has stimulated interest in Wireless Sensor Network (WSN) research and deployment. WSN are automated, self-configuring and wireless communication capable. Therefore, WSNs have commonly been used to sense changes in the environment such as temperature changes.

The low cost of sensor hardware, ease of maintenance and the ability to self-configure when randomly deployed enables sensor nodes to be deployed in remote and dangerous places to collect and transmit data. In addition, a WSN can be easily deployed and has low maintenance and installation costs. However, a WSN has a limited energy source, which imposes a challenge that needs to be addressed. This is because a sensor is battery powered and a battery's lifetime is limited. Furthermore, the energy consumed by a sensor during transmission is thousands of times greater than that used in computation. If a sensor transmits all sensed data back to the server, then its energy source will be depleted quickly. As a result, the sensor's battery will need to be replaced manually, which can be a costly and demanding task.

At present, there is limited research work in the area of audio signal processing in a WSN. The challenge in this area is that audio signal processing is resource intensive and requires a large amount of memory for performing computations accurately. This is difficult for resource-constrained sensor nodes. For instance, if a simple processing technique is applied, although only a small amount of memory and system resources would be required, the result obtained would be less accurate. Conversely, if a more complex processing technique is applied, the obtained results would be more accurate but more energy would be consumed, which would be impractical for a sensors network.

Different families of living animals make different, unique sounds. The same is true for animals belonging to the same family but of a different species or genus. This research targets this unique characteristic of living animals (i.e. sound). Specifically, we study the ten different frog species in Taiwan because: (1) there is little research done on studying animal sounds. Current research work focuses on sounds made by humans and; (2) there is a need to autonomously monitor the frog species that only appear at unconventional hours, i.e. during the wet season for mating or during nighttime.

In this research, the sound identification technique used is known as SMDF. In this technique, the detected sounds are first processed at the sensor node to extract characteristic features of the sound such as the high pitch and compare against the high pitch distribution state. Then, the sensor determines whether to transmit the sound to the server for further analysis or removes it entirely. At the server, existing classification methods such as GMM are then used to determine the frog species that the sound has originated from. In essence, SMDF uses a simple pitch distribution state comparison technique to correctly distinguish sounds, performing autonomous analysis and decision making to reduce sensor energy consumption and prolong sensor network lifetime. This in effect reduces the need for manual battery replacement.

This paper is organized as follows: Section 2 describes related work pertaining to WSN and audio processing techniques. Section 3 introduces our research and details the proposed technique. Section 4 describes our experiments and the results obtained. Lastly, section 5 discusses conclusions.

具長時間音訊觀測之無線感測器網路設計

1. 前言

現代科技的快速發展，無線傳輸技術漸趨成熟，電子產品的開發也以體積小、方便攜帶為發展目標，這使得 WSN 的研究與應用也逐漸普及。WSN 具有可即時監控、不需事先佈線、無線傳輸等特性，因此目前多用在偵測周遭環境的改變，如溫度等。

sensor 的低成本、用完即可棄置與任意擺放也能互相傳輸資料的便利性，使研究者能將 WSN 應用在人煙稀少的危險區，以進行資料的收集與回傳，使用上不但很方便，還可以省下龐大的佈線與維護費用。但 WSN 在應用上有個重要的限制需要解決，即電力耗損。因 sensor 的電力是由電池供應，電池供電的持續時間不長，而 sensor 一次無線傳輸所耗費的電力可以提供 sensor 做數千到數萬次的內部運算，若 sensor 一接收到資料就全部傳回 server，那電力耗盡會常常發生，這時人員奔波兩地來更換電池就變成繁瑣的工作。

目前把音訊處理技術應用在 WSN 上的研究仍不多，且由於音訊處理技術耗費的記憶體與處理器資源甚大，對處理功能並不強的 sensor 而言，要兼顧系統執行效能、即時運算與比對的準確度將是一大挑戰。sensor 上的簡單運算可以達到即時辨識的要求，也不需耗費太多的記憶體與系統資源，但準確度會受到不小的影響，相反地若是使用複雜的演算法，雖然可以獲得較佳的辨識率，但對系統資源是一大負擔，也無法適用在 WSN 上。

由於不同科別(family)的生物之間通常有其獨特的叫聲，即使是同科但不同屬別(genus)或不同種別(species)的叫聲也不盡相同。因此本研究針對這個生物特性，並選定棲息台灣的數十種蛙類為觀測對象，除了因為現在聲音辨識技術多用在人聲上，對生物音的辨識研究還不是很多，另一個原因是蛙類除了會在繁殖季節的白天下雨天出現求偶外，其他時間多在晚上活動，與人類主要活動時間不盡相同，因此對觀測者而言，最好是能有個自動化的辨識系統來協助觀測生物。

本研究中，使用到的辨識技術主要是 SMDF，將偵測到的聲音先在 sensor 進行音高等特徵值的擷取，再利用音高的分佈型態來比較，以決定是否要將特徵值傳回到 server 做進一步分析，或在 sensor 就把資料刪除。而在 server 則使用其他過去已提出的分類演算法，如 GMM 等來分析判斷這些聲音特徵值是哪一類的蛙類，以驗證簡單的音高分佈型態比較法是否能正確辨識聲音，藉由這種自動觀測、分析與判斷的方式，來減少 sensor 電力消耗，延長 sensor 運作時間，避免因經常更換電池造成的人力浪費。

其他章節結構如下：第 2 節是與 WSN、音訊辨識技術相關的文獻探討。第 3 節介紹本研究的架構與研究方法。第 4 節說明實驗環境設定與結果。最後第 5 節是實驗後得到的結論。