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.

以延长音信观测的无线感知器网络设计

1・ 引言

在无线通讯技术的快速发展与日趋成熟下，小体积以及可移动性逐渐成为设计电子产品的主要标准。这触发了对无线感知器网络（WSN）设计与部署的研究。WSN 具有自我调节性和无线通讯能力。因此，WSNs 被普遍运用于感知外界环境的变化，例如温度变化等等。

低硬件成本、高可维护性以及随机部署后的自我调节能力使得传感器节点可被部署到偏远和危险的地方以传输数据。此外，WSN 可被较容易的部署并且其维护及安装费用都很低。然而，需要解决的是 WSN 的能量局限问题。这是因为感知器是由电池供电的，而电池的寿命是有限的。并且感知器传递信号所消耗的能量是其运算所消耗的能量的数千倍。因此感知器的电池需要进行昂贵繁琐的人工更换。

目前，关于 WSN 对声音信号处理的研究还很少。问题的难点在于声音信号处理非常耗费系统资源，需要大量的内存以进行准确的运算。这对于资源有限的感知器节点是一大难题。例如运用简单的处理技术可以降低内存需求并节省系统资源，但是其取得的结果也不准确。相反的，运用复杂的处理技术可以取得较为准确的结果，但是其消耗的能量将大幅增加，使得 WSN 无法适用。

不同科别（family）的动物通常有其独特的叫声，即使是同一科别不同属别（genus）或不同种别（species）的动物叫声也不尽相同。当前研究以动物的特性－声音为目标。具体来说，我们研究台湾的 10 种不同蛙类因为（1）目前对动物声音的研究还很少而当前研究都集中于人类产生的声音（2）自动观测只有在非常规时间内才出现的蛙类。例如在潮湿的季节中，夜间进行交配。

在这一研究中使用的声音鉴别技术是 SMDF。当运用这种技术时，搜集到的声音信号首先在感知器节点进行处理以提取声音特征，例如提取高频并比对于高频分布状态。之后，感知器自行判断是将声音信号传输到服务器以进行进一步的分析还是直接删除声音信号。在服务器端的分类算法（如 GMM 等）被用于确定发出此声音信号的蛙的种类。SMDF 运用一种简单的音频分布比较技术以正确地区分声音信号并自动地进行分析及决策，从而减少感知器对能量的消耗并增加感知器网络的工作时间，最终达到减少人工更换电池的次数。

其它章节结构如下：第 2 节对 WSN 和声音信号技术相关的文献进行探讨。第 3 节介绍本研究的架构与研究方法。第 4 节阐述试验环境设定与结果。最后第 5 节给出研究结论。