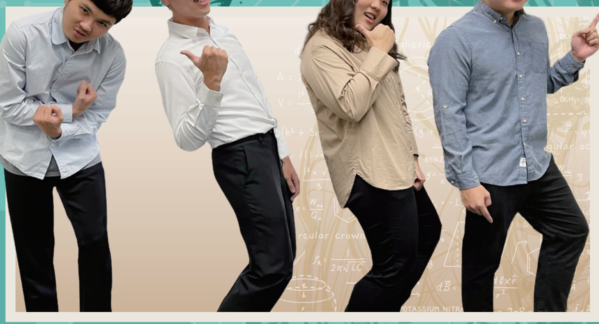
A21-028

熱極聲悲—超聲波二維熱點追蹤系統

Hot and Sound – Ultrasonic 2D Pyrometer



隊伍名稱

老師體脂9

My Professor's Body Fat Is 9 Percent

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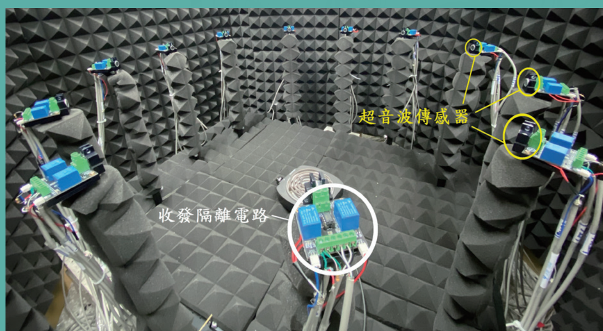
作品摘要

目前市面上測量溫度分佈的方式不勝枚舉，有些使用侵入式或接觸式途徑取得待測物溫度資訊，如熱電偶；有些則使用非接觸方式，藉由接收待測物表面之輻射熱，並將其轉換為溫度資訊，如紅外線溫度計、熱顯像儀。然而，以上的測溫方式皆較適用可見的固態或液態物體，若是針對於氣體之溫度分佈量測，熱電偶型溫度計擺置的數目需對應到待測環境的面積或體積，成本與實驗環境不一定能被接受。倘若欲使用可用於氣體之熱顯像儀，除了所費不貲，充斥在空氣中的灰塵與煙霧，也會大幅降低量測精度。

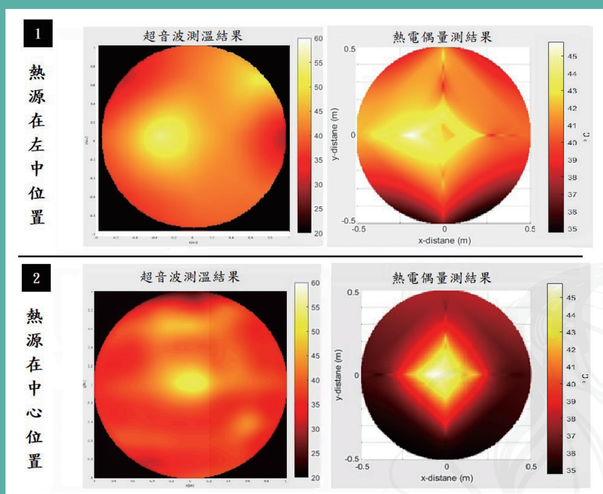
此專題主要使用超音波技術，在待測空間外擺置12顆超音波傳感器，排列成一環形陣列，使用一發多收機制，進行12組連續的聲波收發實驗，經使用H橋電路驅動發射端超音波傳感器，聲波發射廣角範圍可達150度，可充分利用於每顆超音波傳感器之傳送與接收範圍。此外，每組超音波傳感器後端個別安裝了自行設計之類比收發隔離電路，可避免激發傳感器之高電壓毀損前置放大器之輸入端，超音波傳感器陣列與收發電路的架設，如圖一所示。

聲波訊號收集方式為利用同一顆傳感器(40R-16B)進行發射音波與接收音波功能，並以每秒兩千萬的取樣數作為類比轉數位采樣率，可精確區別超音波訊號(40kHz)與外部耦合雜訊。接著使用我們實驗室開發的演算法，可優化接收之聲波訊號及濾除過多的環境干擾雜訊，以精準地計算出個路徑之聲速，並重建成待測範圍之溫度分佈圖，最後再搭配外接37組熱電偶，來進行系統的可靠性驗證，其結果與超音波測溫系統上之結果相互匹配，如圖二所示。

此研究可應用於許多場所，如室內氣體溫度監視，工廠中的煉鐵爐溫度監控等等。若將此系統設計成給水或特定液體的規格，也可以應用於其中，觀察其溫度分佈變化等等。多方位的適應能力、非侵入式的特性、寬廣的掃描範圍與經濟的成本考量，都是超音波技術應用的最佳代表，也是完成此研究的最佳功臣。



▲ 圖一 超音波傳感器陣列與收發電路



▲ 圖二 超音波測溫結果與熱電偶量測結果比較

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成功大學電機工程學士、碩士，美國德州農工大學電機工程博士，現為成功大學電機工程學系助理教授。曾任美國貝克休斯資深研發工程師、比利時校際微電子中心博士後研究員、美國德州農工大學電機工程系博士級研究助理。

研究領域

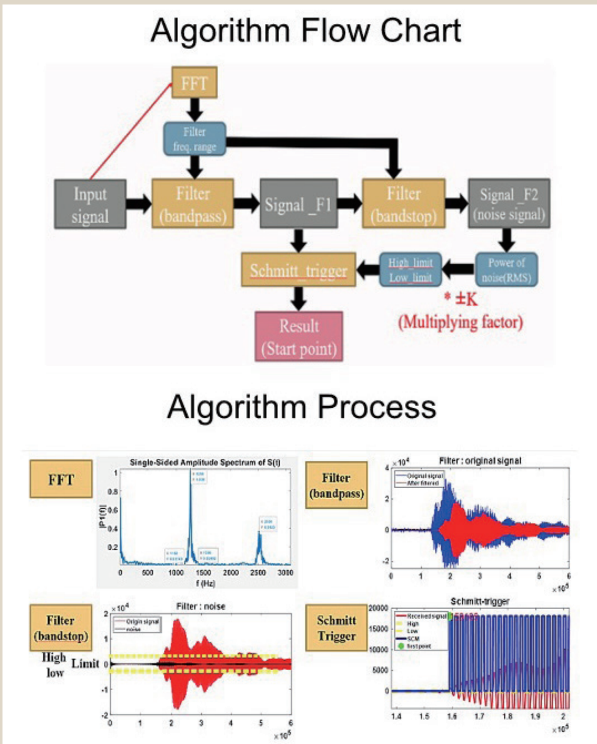
超音波與光聲影像儀器設計與訊號擷取、微機電超音波元件之設計 / 模擬 / 量測、超音波創新應用之模擬與實作、微機電元件之有限元素分析與理論模型推導

Abstract

Several techniques have previously been developed to measure temperature in real-time within the region of interest (ROI). In the past, considerable effort was expended in developing robust and accurate temperature measurement techniques. Thermocouples are the most widely used sensing devices, but drawbacks such as intrusiveness, single-point sensing, and corrosion in harsh environments make them difficult to use in certain conditions. Non-invasive techniques, such as infrared thermometers and thermography cameras, have some disadvantages of being expensive, having a limited range, and the accuracy can be easily affected by dust and smoke which usually exists in a high-temperature environment. As a result, the focus of this work is on the use of ultrasound technique, which is not limited by the afore-mentioned factors and has simpler instrumentation.

In this work, the ROI is surrounded by 12 ultrasonic transceiver units (TUs) of 40kHz. The measurement procedure is divided into two sections: transmitting and receiving. During transmission, one TU acts as an emitter, while the remaining TU acts as a receiver. The cycle continues until all the TU has fired. The transmitting TU is driven by the H-bridge circuit, and a wide range of acoustic transmission angle up to 150° could be efficiently implemented to record the acoustic signal at the receiving end. The TUs are isolated from one another to prevent the high voltage used to excite the ultrasonic transducer from damaging the input terminal of the pre-amplifier circuit. To successfully capture the ultrasound signal at the receiving end, each TU is followed by an analog-to-digital convert. Next, the capture signal is filtered using a custom signal processing technique to calculate an accurate ultrasound velocity, which is then used to reconstruct the 2D temperature distribution map for the ROI, as shown in Fig. 3 The temperature values are also collected using a 37-thermocouple array and interpolated into a 2D temperature distribution map. As a verification step, the thermocouple result is compared to the ultrasonic temperature measurement.

Therefore, research can be applied to a variety of fields, including indoor gas temperature monitoring, blast furnace temperature monitoring, and so on. The ultrasound technique can successfully measure temperature in solid, liquid, and gas environments. The best representative of ultrasound technique is multi-aspect adaptability, non-intrusive feature, broad scanning range, and economic cost consideration. It is also the main characteristic for implementing this research topic.



▲ Fig. 3 Algorithm flow chart & process