信号处理 2011, 27(10) 1457-1463 DOI: ISSN: 1003-0530 CN: 11-2406/TN

论文与技术报告

THz-TDS信号的相似性度量及其应用

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摘要:

太赫兹(Terahertz, 简称THz)波段位于微波和红外线之间,属于远红外线和亚毫米波范畴。太赫兹时域光谱(Terahertz time domain spectroscopy，简称THz-TDS)信号脉冲具有宽频带特性，其中蕴含了丰富的信息，但同时也给THz-TDS信号的分析和处理带来了困难。太赫兹时域光谱信号的处理和分析还处于起步阶段。基于几何代数理论，本文首先将在频率域上的THz-TDS信号表达为高维实矢量空间中的矢量，并对这些矢量使用几何代数中的超复数来进行描述。针对THz-TDS信号的特点，本文引入矢量外积定义了THz信号矢量的相似性函数，以此来度量THz信号的差异。同时本文还使用几何代数语言定义了矢量间的欧几里德距离，并且分别推导欧氏距离和相似性函数的具体计算方法。最后，本文具体地将这两种度量应用于THz-TDS信号的分类和辨识中，并和传统的欧氏距离进行了对比实验。本文给出的实验验证了这两种度量的可行性和有效性，并且表明本文提出的相似性函数相比于欧氏距离具有更好的抗干扰能力；特别的，在待辨识的物质种类较多和信号集波形出现混杂的情况下，本文提出的信号矢量间相似性函数能更好地度量THz信号之间的差异。

关键词： 太赫兹； 太赫兹时域光谱； 几何代数

Similarity metrics and their applications of THz-TDS Signals

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Abstract:

The Terahertz (THz) band is between the microwave band and the infrared wave band. It belongs to the category of the far infrared wave and sub-millimeter wave. The terahertz pulsed imaging system delivers the terahertz time domain spectroscopy (THz-TDS), which has a broad wave band property. Such THz-TDS signals not only contain plentiful information but also bring obstacles to the signal analysis and process. Nowadays, the process and analysis of THz-TDS signals are at the beginning stage. Using the geometrical algebra (GA) and based on the physical basis of THz-TDS signals, THz signals were first mapped into vectors in the high dimensional space, and were represented as hyper-numbers. Then, two similarity metrics, the Euclid distance and the similarity function were defined in the language of geometrical algebra, and were used to measure the similarity of the corresponding THz-TDS signals. Detailed computation methods of the metrics were also deduced and presented respectively. And furthermore, those metrics were applied practically in the substance classification and the substance identification based on the THz-TDS signals. Finally, the feasibility and validity of those two similarity measurements are verified by the given experiments. These experiments show that: on condition that signals are obviously distinguished from each other and only a few of the substances are to be identified, all metrics perform well in the substance identification; while on condition that signals are congregated and many substances are to be identified, the similarity function presented performs best.

Keywords: Terahertz THz-TDS geometric algebra

收稿日期 2011-06-02 修回日期 2011-09-05 网络版发布日期 2011-10-25

DOI:

基金项目:

国家自然科学基金资助项目（No.61071206）;深圳市科技计划项目

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