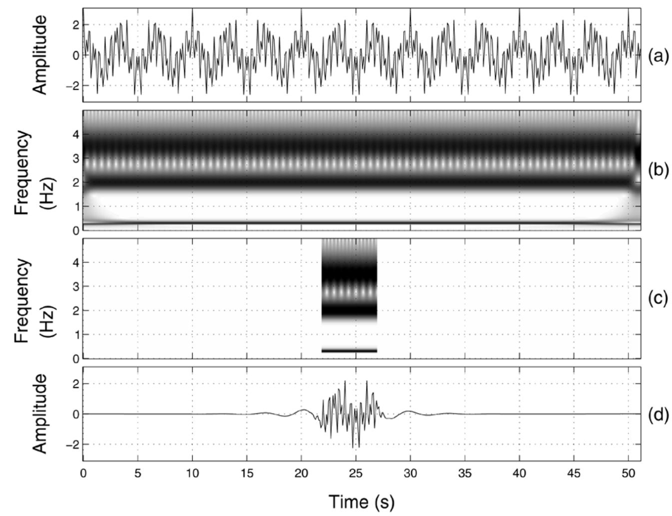

Fig. 4. (a) Superposition of synthetic 0.3-, 2-, and 3.5-Hz cosine waves, all of unit amplitude, sampling frequency 10 Hz, and duration 51.2 s. (b) S-transform of this synthetic signal, showing multiple bands. (c) Muted S-transform after multiplication with zero at $t < 22$ and $t > 27$. (d) Reconstructed time series $\hat{u}_{\mathrm{filt}_1}[t]$ after filtering, showing differences from Fig. 1(e) of [1].

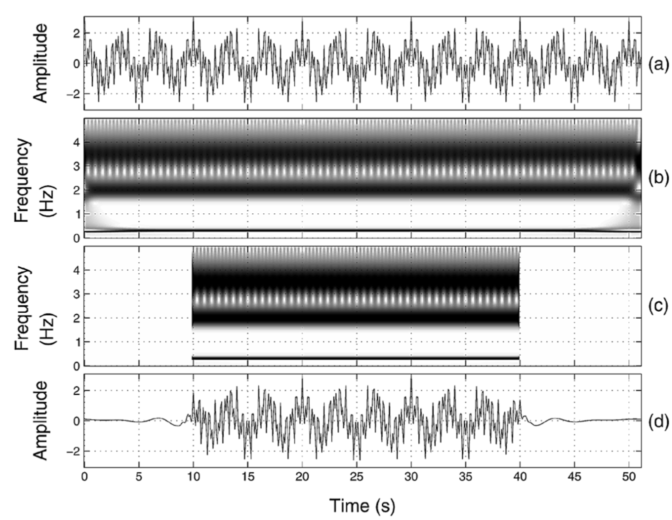

Fig. 5. (a) Superposition of synthetic 0.3-, 2-, and 3.5-Hz cosine waves, all of unit amplitude, sampling frequency 10 Hz, and duration 51.2 s. (b) S-transform of this synthetic signal, showing multiple bands. (c) Muted S-transform after multiplication with zero at $t < 10$ and $t > 40$. (d) Reconstructed time series $\hat{u}_{\mathrm{filt}_1}[t]$ after filtering, showing differences from Fig. 1(f) of [1].

of $u_{\mathrm{filt}_2}[t]$, which are visually almost indistinguishable from the corrected $\hat{u}_{filt_2}$ results. The long and short of this is that the new filtering technique, in its corrected form, does still appear to give a faster time taper than the older method, but the improvement is not as marked as implied by [1]. Determining whether a filter based on (12) really works better than the discrete form of ([1]-(7)) will require more investigation of both the time and frequency responses of the two techniques.

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Authors' Reply to Comments on "The Inverse S-Transform in Filters With Time-Frequency Localization"

M. Schimmel and J. Gallart

***Abstract*—Pinnegar points in his comment to a mistake in our paper on the inverse S-transform. It seems, in fact, that the error should mainly be attributed to the discretization of the S-transform, not to our inverse S-transform. Pinnegar bases his approach on the discrete S-transform by using its representation in the frequency domain. It is shown in an accompanying paper by Simon *et al.* that there are differences whether one discretizes the S-transform using the time-domain or the frequency-domain expression. As a consequence, both inverse S-transforms suffer from different small artifacts. There are no changes in the physics, understanding, and conclusions of our publication.**

I. Introduction and Discussion

In [1], we noticed that the routine inverse S-transform can cause spurious signals in filter applications for feature extraction and noise attenuation. These artifacts may happen when one modifies/weights the time-frequency spectra before their back transform to the time domain. In [1], we discuss these effects and propose an alternative inverse S-transform (equation (10) of [1]), which we test with theoretical data and seismic recordings from a distant earthquake.

Pinnegar mentioned a mistake in [1], which he exposes together with a correction in his comment [3]. Reference [4] shows two ways of computing the S-transform: in the time domain (we will call it the *time-ST*) and in the frequency domain (*freq-ST*). Although, equivalent in the continuous case, [2] proves that they are different in the discrete case. Pinnegar's correction has been derived using the discrete freq-ST and our inverse S-transform (time-IST). The routine inverse S-transform [4] will be called *freq-IST*.

Pinnegar's function $A_N[f]$ (equations (10) and (11), and Figs. 1(c) and 2(c) in [3]) should equal one for an exact inverse. It is visible from these figures that using the freq-ST followed by our time-IST leads to an error at the fundamental frequency ($df \approx 0.02$ Hz in our example) that is at the period that equals the length of the time series. This can be corrected using $A_N[f]$ or, on a more provisional basis, by just excluding these frequencies (applying a high-pass). Anyhow, we believe that $A_N[f]$ is not due to an error in our time-IST, but due to the mistake that one does by applying the discrete freq-ST in combination with a discrete time-IST.

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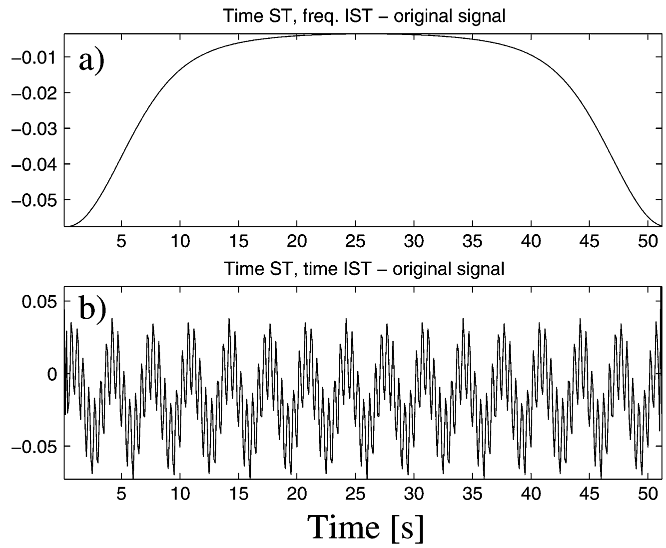

Fig. 1. Error in the reconstruction of the sum of the three sine functions used by [1] and [3] in their Fig. 1, respectively. The S-transform has been computed by discretizing its time-domain expression rather than its frequency-domain expression.

Fig 1(b) of [3] shows the error in the reconstruction of the data from Fig. 1(d) of [1] (sum of three sine functions at 0.3, 2, and 3.5 Hz). Reference [3] uses the time-IST and freq-IST in combination with the freq-ST. In analogy, Fig. 1 shows the measured error of the time-IST and freq-IST in combination with the time-ST of the same data. By comparison with Fig. 1(b) of [3], it can be seen that the freq-IST and time-IST perform best on spectra obtained with the freq-ST and time-ST, respectively. The error is largest for the mixed combinations, that is, time-IST and freq-ST and freq-IST and time-ST. Furthermore, the error at the fundamental frequency vanishes for the time-IST in combination with the time-ST [Fig. 1(b)]. It seems from this example that the original signal is better retrieved using the freq-IST. Nevertheless, the time-IST provides a good approximation as also noticed in [3]. The S-transform, both inverse S-transforms, and the discretization errors are further discussed and illustrated in [2]. They show also examples where the time-IST performs better than the freq-IST. Furthermore, it is shown why the time-IST works.

As observed by Pinnegar, there is a mistake in the plots concerning the traces obtained with the freq-ST ($u_{\mathrm{filt}_1}[t]$). This has no influence on the time-IST by [1] and does not change the physics, our understanding, and conclusions concerning our new approach. Pinnegar writes, "The long and short of this is that the new filtering technique, in its corrected form, does still appear to give a faster time taper than the older method, but the improvement is not as marked as implied by [1]." Reference [2] shows that the improvement depends on the filter and data as also on how one has discretized the S-transform.

As already mentioned in [1], the S-transform is a powerful method used in several motivating studies to analyze time-varying signals. As with any method, one should be aware of limitations, and the choice of the proper approach depends on the data and application.

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A Fast and Effective Multidimensional Scaling Approach for Node Localization in Wireless Sensor Networks

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***Abstract*—Given a set of pairwise distance estimates between nodes, it is often of interest to generate a map of node locations. This is an old nonlinear estimation problem that has recently drawn interest in the signal processing community, due to the emergence of wireless sensor networks. Sensor maps are useful for estimating the spatial distribution of measured phenomena, and for routing purposes. We propose a two-stage algorithm that combines algebraic initialization and gradient descent. In particular, we borrow an algebraic solution known as *Fastmap* from the database literature, adapt it to the sensor network context, and motivate the placement of anchor/pivot nodes on the edges of the network. When all nodes can estimate their distance from the anchors, the overall algorithm offers very competitive performance at low complexity (quadratic in the number of nodes).**

***Index Terms*—Multidimensional scaling, node localization, sensor networks.**

I. INTRODUCTION

The problem of node localization from pairwise distance estimates has recently attracted interest in the signal processing community, owing to the growing interest in wireless sensor networks [2], [3], [5], [8], [9]. Given a matrix of pairwise distances, the localization problem aims to determine the (*relative*) node locations that generate these distances. In other words, one seeks a map of node locations with a given (approximate) distance structure. This is a classic problem originating in psychometrics [10], [11], known as *multidimensional scaling* (MDS) [6]. There are many MDS flavors and variants; perhaps the single most important one is *metric MDS*.

The classical approach to solving MDS is based on computing the principal components of a double-centered version of the matrix of squared distances. This works reasonably well (albeit not optimally in the least squares sense, due to the double centering), but its complexity is cubic in the number of nodes, and thus does not scale well

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