DUPLICATING FILTERS: A CLASS OF DIGITAL FILTERS WITH AN INVARIANCE PROPERTY

by

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ABSTRACT

When the sampling rate of a signal is changed, i.e. multiplied or divided by an integer, there is the possibility of distortion unless filtering accompanies the process of rate changing. When the rate change has many factors, there is often a large economic advantage to realizing this rate change as a sequence of smaller changes, with distortion prevented by a filter at each stage. the basic element of this process is the unit cell, which consists of a time invariant filter in series with a sampler operating at the output sampling rate.

In the present investigation, the properties of a chain of such unit cells are studied. Unlike time-varying filters in general, the impulse response is a function of only a single time. When two unit cells are connected in series. the result is equivalent to a single unit cell with rate change equal to the product of the rate changes in the two original unit cells. In general, two unit cells do not operate commutatively when connected in series. Consider a set of impulse responses, one for each rate change, and use each impulse response as the filter in a unit cell having that rate change. A set of duplicating filters has the property that when two such unit cells are connect in series, the impulse response of the filter in the equivalent unit cell is also a member of the set. These unit cells operate commutatively.

There exist sets of duplicating filters, studied in chapter 6, in which all the member impulse responses are impulse-invariants of a single continuous-time function. Thus, when two unit cells using these are connected in series, the shape of the impulse response does not change.

Given an arbitrary impulse response and rate change, there is a set of duplicating filters in which the given impulse response is the member of the set corresponding to the given rate change.

The set of impulse responses of a cascade of an arbitrary number of boxcar integrators, each having duration equal to the change in sampling rate, is a set of duplicating filters. The practical aspects of the use of these filters are considered. They are suitable for use in a wide variety of signal processing applications, and the simple structure, consisiting mostly of shift registers, is appropriate to large scale integration.

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