TITLE OF RESEARCH WORK: A FRAMEWORK FOR IMAGING SENSOR SIGNAL REPRESENTATION THEORY

Research Description:

As a framework we define two areas analysis and computation, that will be explained later.

A useful processing tool for time-frequency signals is the 1-D Discrete Chirp Fourier Transform (DCFT) operator. A Time-frequency signal is defined as a signal whose spectral distribution changes with time. Chirp signals are time-frequency signals which are linearly frequency modulated and are widely used in RADAR applications.

A new methodology for the formulation of Discrete Chirp Fourier Transform (DCFT) algorithms and it discusses performance measures pertaining to the mapping of these algorithms to hardware computational structures (HCS) as well as the extraction of chirp rate estimation parameters of multicomponent nonstationary signals arriving from point targets.

WALSAIP GROUP ASSOCIATION:
Automated Information Processing Group

THESIS TITLE:
CHIRP SIGNAL ANALYSIS, COMPUTATIONAL IMPLEMENTATIONS APPLIED TO TARGET DETECTION IN SAR IMAGES.

THESIS ADVISOR:
Prof. Domingo Rodriguez

INSTITUTION:
Electrical and Computer Engineering Dept.
University of Puerto Rico at Mayaguez

PERSONAL WEBSITE:
www.ece.uprm.edu/~caceros

NAME OF RESEACH ASSISTANT:
Cesar A. Aceros Moreno

RESEARCH PROJECT OUTCOMES:

Publications:

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Santiago, Nayda; Aceros Moreno, Cesar A.; Rodriguez, Domingo. “Performance measures for parameter extraction of sensor array point targets using the Discrete Chirp Fourier Transform”. Signal Processing, Sensor Fusion, and Target Recognition XV. Edited by Ivan Kadar. Proceedings of the SPIE, Volume 6235, pp. 623519 (2006).

Aceros, D. Rodriguez, “Fast Discrete Chirp Fourier Transforms for Radar Signal Detection Systems Using Cluster Computer Implementations,” IEEE International MWSCAS 05, Ohio, USA, 2005.

Tools and Applications:

The work that we are doing can be divided in two large areas:

Analysis Framework: In the analysis framework we are interested in formulating the inherent attribution associated with sensor signals.

In this area is included "*modeling*" defined as: A set of mathematical expressions that describe an aspect of the physical world.

Computational Framework: In the Computational Framework of our research we are interested in the computational complexity associated with a specific task or work.

In this area "*simulation*" defined as: The auctioning of a model. The implementation and application to real situations.

With this introduction we can explain one of the problems that we expect deal with. Basically 3 problems are defined:

1. Multiple point target dynamics.
2. Correlated interferometry for change detection.
3. Radar signal processing for detection and estimation.

Problems 1 and 3 are clearly related with one particular application that is the Chirp Fourier Transform. One of the biggest problems with the DCFT is the computational complexity involved in the transform. For this reason we are working in two directions. A first one generating mathematically algorithms that reduce the computational complexity of the DCFT and second, implementing algorithms of the DCFT in computational structures that can support our work. For the implementation of algorithms for the DCFT we are working with three tools.

- An IBM Cluster This cluster is a Linux Beowulf Cluster (Komolongma) that consists of 65 2-Way SMP Intel Pentium III CPU 1.2GHz with 1 GB of Memory. This Cluster runs MPI, and running applications for the DCFT have been implemented.

- Matlab and C implementations of the DCFT running in a PC at the AIP laboratory.

- At this moment we are working in Planet Lab (http://www.planet-lab.org) as platform for the implementation of New Algorithms for the DCFT.

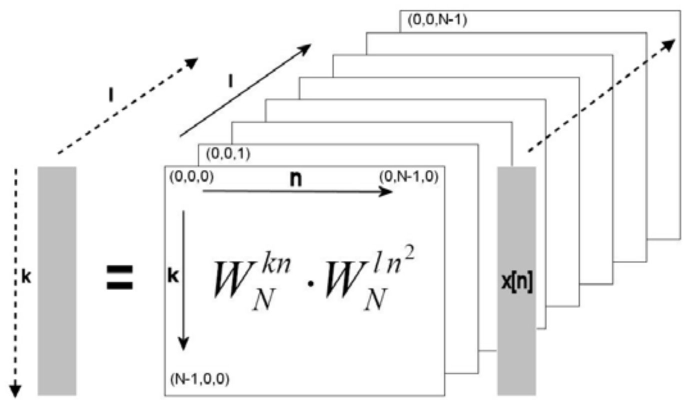
AIP LAB AUTOMATED INFORMATION PROCESSING LABORATORY
NATIONAL SCIENCE FOUNDATION
ICIS Institute for Computing and Informatics Studies
WALSAIP

RELATION OF RESEARCH WORK TO WALSAIP PROJECT:

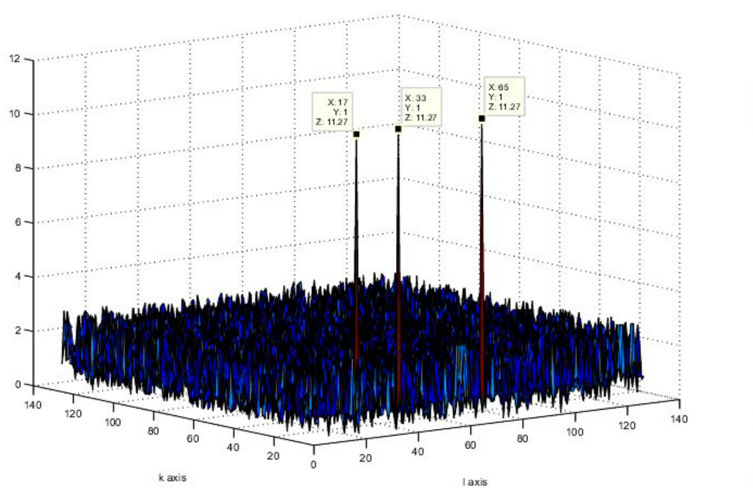
The detection of targets is an important issue in the work of the AIP laboratory because we can determine characteristics of the signals that we receive from different types of sensors. An special attention is given to SAR signals where Chirp Signals are involved so often. The development of ways to detect chirp components in signals is a promising work.

The analysis of the DCFT and the presence of Chirp Signals in the world could be another approach to the problem of detection of changes in images. Another application where the DCFT is suitable to use is the detection of target (or multi-target) behavior and estimation of the parameters.

IMAGE REPRESENTATIVE OF RESEARCH WORK:

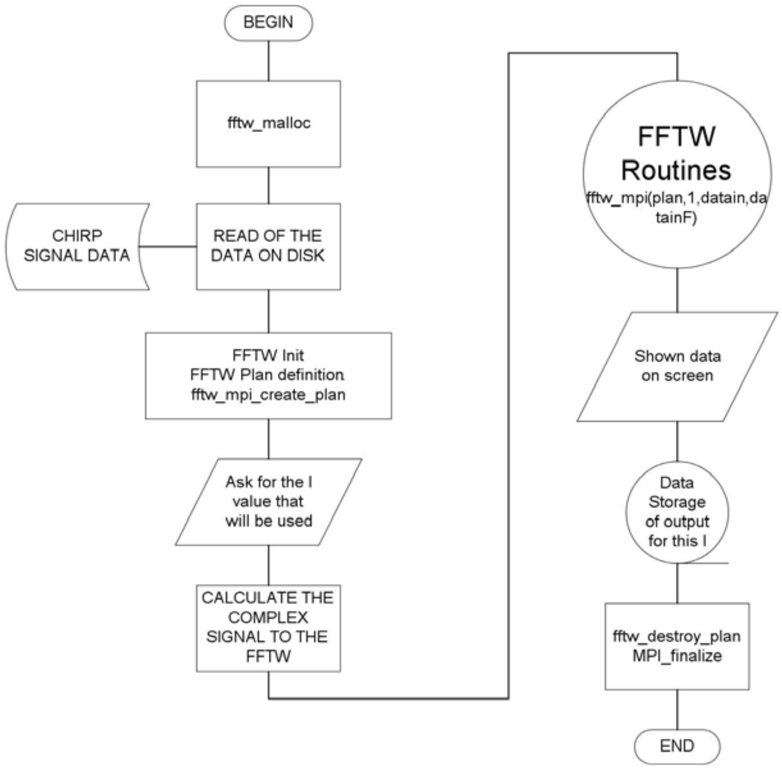


This figure is a graphic representation of how the DCFT is computed. We have N matrix-vector products that generates a complexity of O(N^3).



This is the output of a DCFT. The peaks are the Chirp Signals detected by the DCFT.

RESEARCH DEMONSTRATION:



This is a workflow of the implementation in the MPI Cluster. The results of this implementation in comparison with the Matlab implementation are in the following table.

Samples	Matlab Implementation. (Seconds)	Cluster implementation (Seconds)
64	0.06	0
128	0.23	0.05
256	0.90	0.21
512	3.64	0.97
1024	14.92	4.19
2048	62.11	17.72
4096	-	74.06
8192	-	310.20

The work is now in the implementation of a multiprocessor processing of the DCFT in the Planet-Lab. Computational environment. Additional to this we want to work automatically data generated in the Planet-Lab with the applications developed.