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13. ABSTRACT (Maximum 200 words) Research has focused on the development, characterization and implementation of algorithms for time varying ionospheric imaging. Several techniques were used including neural network based approaches for imaging localized time varying events, an iterative volumetric approach for three-dimensional imaging that enables localized incorporation of a priori information, and a technique that utilizes both TEC data as well as information from the WSBI system. Considerable effort was made to analyze the strengths and weaknesses of the various approaches and their inherent limitations. Tests were made using both real and simulated data.				
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Final Report for ONR N00014-97-1-159

The research performed under this grant has focused on the development, characterization and analysis of algorithms for imaging the ionosphere. Research has also been performed on developing a time-varying imaging algorithm, capable of examining time varying ionospheric features. This is key for future studies of the E-layer. In addition, research was performed on techniques for incorporating multiple sources of ionospheric data, as would be available from a ROTH site. Details on various components are below.

First, we developed a novel neural network based approach to imaging ionospheric motion. The algorithm employs neural networks as estimators of a time varying electron density distribution; however the networks are not used to estimate the electron densities directly but rather the change in electron densities at each time step.

At each time step, the method consists of four main parts. First, a ray tracing procedure is used to calculate ray path information for the current time step; this information is used to determine the expected measurement values based on the last time step. Second, the expected measurement values are subtracted from the actual measurement values. This information, along with the ray path geometry, is then preprocessed so that it can be used by the neural network. Third, the neural network is trained using the pre-processed data. Fourth, the network is used to produce an electron density estimate for the current time step.

Preliminary experimental results indicate that ionospheric electron density estimation using this method is both computationally feasible in real time and capable of producing reasonable reconstructions given the proper choice of neural network. In particular, a two layer neural network trained using the Levenberg-Marquardt method was found to be capable of locating a localized time-varying Gaussian depletion type ionospheric disturbance based only on very sparse data.

Second, we have worked on the development of a new fully 3D reconstruction algorithm for CIT, capable of combining some of the available measurement sources in order to compensate for the unavoidable physical limitations of the acquisition system.

The main features of the algorithm are:

a) Fully 3D reconstruction with arbitrary voxel size. b) Real-time system geometry computation in spherical coordinates. c) Direct (non-iterative) reconstruction based on a least-squares inversion method. d) Physical constraints (e.g. non-negativity of the electron density) and RADAR measurements (e.g. WSBI data) introduced as boundary conditions for the least-squares algorithm. e) No a priori information on the electron density distribution required. f) Ready for acquisition system extension to occultation measurements. When satellite occultation TEC measurements will become available an interface is ready to include them in the reconstruction algorithm system matrix. g) Choice of parameters is minimized. Raw estimates of the measurement errors are the

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only parameters necessary to run the whole algorithm. At this time most of the software features are operative. The package includes a fast 3D ray-tracing algorithm capable of computing a system matrix with arbitrary voxel sizes in real time and storing it in a compressed sparse form.

The bounded least squares problem engine has been tested and optimized for the given problem. A technique to improve the sparseness of the intermediate results generated in the inversion process is under construction. This represents at the moment the factor that limits the size of the system matrix, which can be used without incurring in unacceptable memory requirements.

The inclusion of non-TEC measurement data, e.g. WSBI data, is under development in this stage. On the other side the algorithm gave very promising results simply adding some simple physical constraints in the reconstruction algorithm.

Finally, we worked on developing and implementing CVT (CREDO-VSIRT Technique), studies on the incorporation of WSBI data into VSIRT, and reconstructions for simulated and real data.

The studies on the incorporation of WSBI data into VSIRT entailed understanding the weaknesses of both CREDO and VSIRT, and finding ways to use the strengths of each for the benefit of better reconstructions. Some of the techniques include the initial guess method, the control point method and the method of doing the WSBI inversion within VSIRT.

In the area of reconstructions, the most important result was the simulated test of detecting an E-layer using VSIRT. This test proved that VSIRT was able to pick up an E-layer, but it was only able to do it in a very controlled environment, i.e. ideal station alignment and an E-layer that was quite high in altitude.

Technical details are theses of Robert Granat, Riccardo Boscolo and Rahul Singh.

REPORT OF INVENTIONS AND SUBCONTRACTS
(Pursuant to "Patent Rights" Contract Clause) (See Instructions on back)

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1. a. NAME OF CONTRACTOR/SUBCONTRACTOR UCLA UCLA		c. CONTRACT NUMBER N00014-97-1-0159	
b. ADDRESS (include ZIP Code) Electrical Engineering Box 951594 Los Angeles, CA 90095-1594		b. ADDRESS (include ZIP Code)	
2. TYPE OF REPORT (a) one		d. AWARD DATE (YYYYMMDD)	
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SECTION I - SUBJECT INVENTIONS

5. "SUBJECT INVENTIONS" REQUIRED TO BE REPORTED BY CONTRACTOR/SUBCONTRACTOR (None, so state)	TITLE OF INVENTION(S) a.	DISCLOSURE NUMBER, PATENT APPLICATION SERIAL NUMBER OR PATENT NUMBER c.	ELECTION TO FILE PATENT APPLICATIONS (d)		CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER (e)
			(1) UNITED STATES (a) YES (b) NO	(2) FOREIGN (a) YES (b) NO	
	NONE				

SECTION II - SUBCONTRACTS (Containing "Patent Rights" clause)

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				(1) CLAUSE NUMBER	(2) DATE (YYYYMM)		(1) AWARD	(2) ESTIMATED COMPLETION
	NONE							

SECTION III - CERTIFICATION

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I certify that the reporting party has proceeded for prompt identification and timely disclosure of "Subject Inventions," that such procedures have been followed and that all "Subject Inventions" have been reported.		<input type="checkbox"/>	
8. NAME OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL (Last, First, Middle Initial) Na, Helen. R.	b. TITLE Associate Professor	c. SIGNATURE <i>Helen R. Na</i>	d. DATE SIGNED 1/14/00