Research Activities

Speech Recognition, in a noisy environment for aviation applications
(Task 2)

Investigator: Jide Odubiyi, Sadanand Srivastava

Speech recognition has been a very difficult problem in Artificial Intelligence and Computer Science. The characteristics of speech make it a very demanding problem domain because it represents many aspects of intelligent behavior such as the need to operate in real time, usage of a large amount of knowledge, ability to handle errors, and natural language understanding. In spite of these challenges, the use of voice input to computers provides a lot of advantages because it provides a natural medium for communication, plus hands free, eyes free, and location independent communication.

Technical Approach

This research will perform extensive literature reviews on speech models. Speech models are mathematical models that represent how people speak different phonemes. A speech recognition system uses speech models to determine the correct phrase from human utterance. This research will focus on evaluating speech models for speaker-independent speech recognition systems which does not require training of the system to recognize a particular speaker. It will investigate underlying speech models in speaker independent speech recognition systems at about four universities (including MIT media labs, Columbia University, and Carnegie Mellon University) and Lucent Technologies, Microsoft and AT&T. These tools support accurate, large vocabulary, speaker independent, continuous speech systems.

The research will document, compare and contrast the capabilities of the speech models in the systems above and including dynamic time-warping (DTW) which accommodates time-scale variations, hidden Markov Modeling (HMM), a parametric model for describing speech events, semi-continuous hidden Markov model (SCHMM), continuous density method (CDHMM), and Neural Networks—multi-layer perceptron (MLP).

Deliverables:

We will develop and deliver a report of our research findings. We will also deliver any research prototypes.
Summary of Capabilities:

Dr. Odubiyi has some experience with the design and development of speaker independent speech recognition systems to support Telematics through an effort that was funded by the British Telecommunication Labs. The result of this effort was a telephony-based operational system called Direction Finder which employs speech recognition and speech synthesis to provide travel directions to users. He has also investigated the use of hidden Markov models to support information extraction using intelligent agents in intelligent search engines. He designed and developed a knowledge-based system for the US Air Traffic Control System on an FAA contract while employed at the MITRE Corporation. The prototype was used to resolve air craft in-flight conflicts given each aircraft’s performance capabilities. He conducted research and implemented software prototypes for spacecraft space and ground control segments for NASA GSFC under contract with Lockheed Martin Aerospace. He is familiar with aircraft design, structures, and operations through his experience as a systems engineer at the Boeing Company in Seattle, WA.

Dr. Odubiyi is an Associate Professor, a Principal AI Researcher, Systems and Knowledge Engineer with 25+ years of experience in developing large decision support systems using Artificial Intelligence (AI) including software agent technology, Computer Simulation, Statistics and Operations Research principles. Dr. Odubiyi joined the faculty of Bowie State University in fall of 2002 where he teaches graduate and undergraduate courses in Computer and Network Security, Artificial Intelligence, Distributed Computing, Java and C++ programming. He also conducts research in Grid Computing and computer and network security. He earned a Ph.D. in Computer Science from Kennedy Western University in 1990, and a Ph.D. in Decision Sciences from Walden University in 2003. He earned three degrees from the University of Washington in Seattle (BSME '73, BSIE ‘74, and MSME ‘75).

Selected Publications:


Development of Methods for Extracting Maps from Photos (Task 10)

W. Lawrence – BSU

CIBAC Tasks & Activities – To-date and Future

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Develop an automated tool or procedure for extracting airport feature maps from aerial photos. There are tools commercially available, but all still require extensive manual intervention. See for example Terra Tools at http://www.terrasim.com/products.html

Statement of Work
Activities/Ideas/Approach

It has been the consensus of this of this work group to broaden the task to include “a broad set of digital data” as the source[s] for airport feature extraction and mapping, rather than the more limited “aerial photos” as stated in the original task description. It is our vision that the inclusion of the broadest set of data sources for feature extraction will allow a near-real-time creation of digital maps and visualizations for use in the aircraft cockpit and for flight planning.

Through our cross-campus group experience in remote sensing and geographic information system [GIS] technologies, we are aware of modern and emerging spatial data integration techniques. Using GIS automation within appropriate software, it should be possible to compile maps and extract features for airports and surrounding areas using many sources of data. We envision maps made from satellite or aircraft images, aerial photography [digital or digitized], and even construction drawings. Using recently acquired data sets the ‘background’ can be seasonally correct in terms of vegetation, and in the case of buildings and on-going construction, CAD drawings and constructions schedules can be integrated to essentially ‘build’ infrastructure in the maps from detailed plans. One could even imaging automatic ‘placement’ of potential runway obstructions and incursions from GPS signals generated real-time by vehicles and/or scheduled use and movement of construction equipment such as cranes, scaffolding and paving or grading plans.

We have laid out general plans for this task, and have accomplished some progress during the first stage of the progress. In general we planned to:

- procure demo CD from TerraSim for Terra Tools visualizer [this is ‘industry standard’]
- compare to new 3-D visualization capabilities in ArcGIS 9.0 [widely used among CIBAC members, common in educational and industrial settings]
- integrate students into project
- expose students to spectral classification/remote sensing
- expose students to feature extraction/classification
- expose students to concept of multi-data-layer geographic information system approach
- determine available vs. optimal data sets for airport feature extraction
- stage airport feature extraction data sets to a map server
- ‘story board’ current vs. future/automated feature mapping procedure – with goal of reducing manual intervention in process
- investigate static vs. dynamic updating
  - static – done on some fixed time schedule
  - dynamic – updated ‘automatically’ when new data available – eg. new construction/building blueprints, new image data or new data from active sensors such as LIDAR
- choose a ‘case study’ airport location for testing
- build an airport feature map for ‘case study’ location using ArcGIS
- develop/evaluate capability for automation of feature mapping

Activities to Date
- Integrate students into project
  - Summer 2004 – students in summer internships at Morgan State; Task 10 students worked with Dr. Wilson at Morgan State – learned basic remote sensing with ENVI
  - Academic year 2004 – 2005 - CIBAC students at BSU worked on collaborative projects; near-real-time MODIS data acquisition, spatial data base development, data evaluation and familiarization, web use
- Data set evaluation/familiarization begun
  - RNO – Reno – NASA LaRC – using LIDAR data
  - High resolution satellite imagery
- SF21 – major US airports – ftp acquired
  - Broad range of data
- Public Domain Holdings
  - TM images, other high resolution data
- Initial contact made with GIS Team – NASA LaRC – can we access Langley data and use Langley as our ‘case study’? [avoid security, data access problems with other airports]

Future Activities
- Select ‘case study’ airport
- Review data holdings/needs
- Acquire data sets
- Stage data on shared resource Map Server
  - Web link to BSU data archives
- Use BSU dedicated CIBAC WebServer for Map Services
• Use BSU Apple Xserve ‘Cluster’ HPC facility for data analysis
• Prototype automated feature extraction/airport mapping with ArcGIS
• Begin collaboration with NASA Langley GIS group
• Set up DBMS/Map Server – Oracle 10G
• Continue and enhance script-based near-real-time data acquisition
Task #4 and Task #6: Lidar/Radar Image Processing  
Manohar Mareboyana, Mark Matties, and William Lawrence

In aviation application’s Lidar data is gaining increasing acceptance for topographic mapping. It is relatively less expensive, faster, and more accurate than conventional methods of topographic mapping using photogrammetry.

While creating elevation models, intensity images can be generated. Lidar-generated images can be helpful in Synthetic Vision System (SVS). QT Modeler is a commercial software that can be used for 3-D visualization of Lidar data. QT modeler also provides intensity images, but does not have some of the image processing capabilities such as improving the image quality by contrast stretching or histogram modification. The other image processing capabilities such as detecting the airport runways, taxi ways and obstacles on the runways will be valuable addition to image processing tools. A Lidar image processing tool is very useful for creating airport databases. The fusion of radar and Lidar data will be useful for identifying the noise sources and glitches in the data.

**Lidar Image Processing using QT Modeler and Matlab Software**

During the first year, the data Reno, Nevada data has been analyzed using QT modeler and Matlab software. The goal for the first year was to:

- Extract intensity images from Lidar swath data
- Develop Matlab programs to detect edges
- Identify runways and Taxiways from the edge map

Figure 1 is obtained by juxtaposing six tiles (2 tiles horizontally and three vertically) of Reno, Nevada airport. Each tile is approximately 2000 pixels/line and 2000 lines. The image is subsampled for display purposes.

We have developed histogram modifications programs in Matlab to improve the quality of the image. We have also developed edge detection programs using a number of different algorithms such as Sobels edge detector, Canny’s edge detector etc. Figure 2 corresponds to a portion of the Figure 1, on which edge results are shown. In Figure 3, the edges corresponding to image in Figure 2 are shown. In Figure 4, the edges are superimposed on the intensity image.

Figure 1. Reno, Nevada Airport image from Lidar Instrument
Image processing tool using Matlab will be continued. Currently we are working on algorithms for identifying runways and taxiways from edge maps and intensity images. The accuracy of detection depends on how accurately we quantify the visual cues of the airport and taxiways.

**Development of Java/C++ programs for Real Time Implementation**

While Matlab software development is continued, we are also involved development of Java/C++ software for real-time applications. The following programs are developed in Java as of to date.

1. Lidar Swath to Intensity image
2. Nearest Neighbor Interpolation
3. Histogram equalization
4. Edge Detection program.
Figure 5: Reno Airport sub-image obtained by swath-image program

Figure 6: Result of nearest neighbor interpolation
Future Research and Development

We intend to develop a tool box to process Lidar/Radar data. The tool box will consist of various programs developed during the first year of this project and programs that will be developed in future. The following tools will be available in the tool box.

1. Conversion of swath-to-image
2. Interpolation nearest neighbor/bilinear/cubic spline
3. Filters to clean the noise such as speckle noise for radar images, salt and pepper noise etc.
4. Image enhancement programs
   a. Scaling to improve the dynamic range of the images
   b. Smoothing
   c. Edge enhancement
   d. Contrast improvement, histogram modification
   e. Detection of edges and line like features
5. Lidar/Radar data fusion for improving feature detection algorithms.
6. Feature detection (Specify the feature such as runways, taxiways etc)

We will also develop a package of Java/C++ programs that will include some of the tools given in the above tool box. This package will be useful for real time Synthetic Vision System (SVS) applications. The programs will also be implemented on clustered computer by using MPI (Message Passing Interface).
Create and Maintain Web Site for Geospatial Database and Acquisition Source Characterizations

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Faculty Participants:
Frederick Wilson (Morgan State University)
William Lawrence (Bowie State University)
Daryl Stone (Bowie State University)

Task Expectations

The task expectation was to “Create and maintain website for Geospatial Database and Acquisition Source Characterizations.” Based on the expectations, we developed the “Statement of Work” listed below:

Statement of Work: Activities/Ideas/Approach

- Survey the Internet and find what Geospatial Database websites already exist.
- Maintain a list (bookmark links) of these websites.
- Meet again, to access what is already available and determine what our website would look like.
- Prototype our website.
  - Research the data that needed to be on the website. Possibly build a metadata base to include:
    - Books
    - grey literature
    - reports
    - journal articles
    - images held by us and others
  - Metadata base should include fields like:
    - Contact person
    - Data type
    - Abstract
    - Who collected the metadata
    - Web URL, location of data if physical available
    - Link to PDF or other holdings
    - And would be searchable
- Develop the website, including metadata base
- Test the website.
- Present the website.
Work Accomplished

The work we have completed thus far can be viewed on the Web at

We keep a “Web Log” of all the work we have done. This “web log” serves two purposes: 1) It displays the work we have done and will continue to do, thus making reports like this easy to create and keep up to date and 2) It serves as a starting point for the Geospatial Database we have been tasked with creating.

Task 7’s Links:

- **Geospatial Links** (Excel Spreadsheet of websites and databases)
- **PowerPoint Presentations**
- **MS-Producer Presentations** (PowerPoint with “talking head”)
  
  WWW Links related to Task 7
- **MODIS-Moderate Resolution Imaging Spectrometer**
- **Metadata Standards**
- **Database Development**
  
  Prototype of Our User Interface
- **UI Prototype**

Future Work

While we have gotten off to a great start, there are a lot of things that need to be completed for Task 7. Following our outline from the “Statement of work”, we are at about this point:

- Prototype our website.
  - Research the data that needed to be on the website. Possibly build a metadata base to include:
    - Books
    - grey literature
    - reports
    - journal articles
    - images held by us and others
  - Metadata base should include fields like:
    - Contact person
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And would be searchable

- Develop the website, including metadata base
- Test the website.
- Present the website.

The Prototype of the Geospatial Database’s Home Page currently looks like this:

This team will work on the following:

- Improve the User Interface
- Install Oracle 10g
- Design and Develop the Database
- Develop the scripts needed to search the database
- Configure the Web Interface to work with the Oracle Database
- Continue to search the Internet for Geospatial Data
- Determine the best way to incorporate the Geospatial Data (found in bullet point above) into our Geospatial Database

**Developing the CIBAC Website**

**Task Expectations**

The second task that I took on was the “Development of a CIBAC Website”. In brief, CIBAC needs a “face” for the outside world! Anybody interested in knowing “The Who? What? When? and Why?” about CIBAC, should be able to get their questions answered at the CIBAC Website.
Team Members

**Faculty Participants:**
Daryl Stone (Bowie State University)

**Work Accomplished**

Development of the CIBAC website took on two phases. The first phase was to survey the software development environment and determine the most appropriate software package to use when developing the website. During the Summer 2004 CIBAC Consortium Meeting, it was agreed that the website should not “be regular.” Our group took that as a challenge and sought the latest in software development.

By the end of the Fall 2004 semester, the team decided to purchase and install “Swish” software (found at [www.swishzone.com](http://www.swishzone.com)). The software was very similar to the popular “Flash” software, but cost much less. Swish software allowed the students to program the website in “multimedia”!

Two things slowed down the development of the website. First, the students had to install, configure and (most time consuming of all the tasks) learn the software program. To add further delay, one student had to be laid off and the other student was needed for Task #7 (Geospatial Database). Therefore, we had to train another student.

**Future Work**

The estimated date of completion is still set at July 1, 2005. The following tasks will be completed before that date:

- Make changes to the website that were suggested during the CIBAC Consortium Meeting at Morgan State University during the May 6th meeting.
- Update the website with data: researcher information, tasks information, etc…
- Configure a webserver (we use a “testing” machine here in our COSC department but would like to obtain a separate server.
- Make any other changes suggested by the BSU “testing” team (consisting of BSU CIBAC Researchers and our Departmental Administrative Assistant)
- Once the website is posted to the web, we will ask ALL CIBAC Members (BSU, Morgan State and UMES) to review it and send email comments to the team.

**Figures in separate file**