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Applications of Digital Image Processing XIV

Andrew G. Tescher
Chair

22–26 July 1991
San Diego, California

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Session 10—Analysis and Theory II
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Conference 1567, *Applications of Digital Image Processing XIV*, was part of a four-conference program on Mathematical Imaging held at SPIE's 1991 International Symposium on Optical Applied Science and Engineering, 21–26 July 1991, in San Diego, California. The other conferences were:

Conf. 1568 *Image Algebra and Morphological Image Processing II*
Conf. 1569 *Stochastic and Neural Methods in Signal Processing, Image Processing, and Computer Vision*
Conf. 1570 *Geometric Methods in Computer Vision*

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INTRODUCTION

The 1991 symposium on Applications of Digital Image Processing XIV brought together a large international group of engineers and scientists. Following the trend of previous SPIE conferences in the image processing field, this symposium attracted several exciting papers from Europe and the far East in addition to those from the United States.

The quality of presentations was high and topics included a large number of diverse applications, including theoretical approaches, specialized architectures, image coding, and medical and various industrial applications.

In particular, several invited special sessions and their organizers deserve special recognition:

- Applications of Image Understanding (J. J. Pearson).
- Hubble Space Telescope Imagery: Problems, Approaches, and Solutions (R.A. Gonsalves).
- Fluid Dynamics and Wavelets Applied to Image Processing (H.S. Wisniewski).
- HDTV Image Transmission (H. Amor).

The reader will find that the published papers are well representative of the exciting field of digital image processing and are indicative of the significant continuing progress in this field. The more recent advances in applications areas, such as in hardware implementations, are particularly noteworthy.

It is a pleasure to acknowledge the technical as well as administrative contributions of the co-chairs.

Andrew G. Tescher
Lockheed Palo Alto Research Laboratory

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SESSION 1

Systems and Software

Chair
Andrew G. Tescher
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Integrated image processing and tracker performance prediction workstation

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ABSTRACT

Extensive research has shown that including target aspect angle measurements from an optical sensor can significantly improve the performance of radar tracking systems. Integrating sequences of target imagery with the kinematic information involves sets of image processing and sensor data fusion algorithms. A workstation has been developed to expedite the analysis of the algorithms and to integrate the image processing with selectable extended-state tracker modules. This workstation can access analog video imagery from a video optical disk controlled by a PC, segment the target in the image, and perform target identification and aspect angle estimation using a database of target models which span the range of possible aspects. The angle information is then "fused" with kinematic data to augment the tracker state estimator. The workstation is implemented with a powerful visual user interface in a UNIX/X-Windows environment, and includes a wide array of image and signal processing algorithms. Interactive modifications of processing sequences and "what if" analyses are easily conducted. The workstation provides a consistent user interface across a variety of applications. This system has also been used to implement phase retrieval and related image recovery algorithms.

1. INTRODUCTION

The performance of radar tracking systems designed to follow highly maneuvering targets can be improved if additional information on possible target future motion is available.[1,2,3] Target aspect angle information can be used to estimate the orientation of the wing plane of fixed wing aircraft and hence the direction of maximum maneuverability (normal to this wing plane). The application of target orientation information to tracking problems typically requires the extraction of three dimensional object orientation information from two dimensional object projections (images), and these techniques must be robust against scale and intensity fluctuations. Approaches utilizing Fourier descriptors and moments have been applied to this information extraction problem.[4,5,6] The extracted target orientation information must be temporally synchronized and rotated to the radar tracker coordinate system in order to be included as additional information to an extended state tracking filter. Extended state radar/aspect tracker analyses then is a multi-disciplinary sensor fusion problem, involving image processing and pattern recognition, estimation and position prediction, and performance improvement assessment. We have developed a modeling and simulation workstation designed to flexibly support such analyses and to extend analyses with a powerful array of support utilities and capabilities.

The workstation includes the following capabilities:

access to time sequenced digital image data,
preprocess the image data (calibrate, threshold, segment, etc),
identify and estimate aspect angles of the target,
rotate aspect angles to radar coordinate system,
time synchronize image and radar data,
select state estimator algorithm,
select position predictor algorithm,
compare predicted positions to known positions.

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These functions are generic to any computer simulation of the radar/imagery tracking problem. The workstation we have developed incorporates these functions in a software executive which integrates graphical user interface, code generators, instructional aids, information processing and data visualization in a comprehensive information processing research tool.

2. THE WORKSTATION ENVIRONMENT

Evaluation of several software packages to serve as the simulation environment, including an image processing system we previously developed for algorithm analyses [7], was based on the following factors :

Portability: minimum machine dependency and maximum adherence to emerging software standards;

Development efficiency: ease of incorporating new functions and routines, and a robust set of existing routines was desired. Ease of performing "what-if" type analyses, and support for code documentation and code generation were also of interest.

Flexibility: A software environment that can be easily utilized for expanded studies in a variety of areas related to signal and image processing was required.

Visual user interface: we sought to maintain a high level of user productivity by providing a high level visual interface to the simulation and to all supporting function.

Based on these criteria and trial examinations of a number of software systems, we selected Khoros, a code which was currently under development at the University of New Mexico Vision Laboratory[8]. This code in many ways represented the natural evolution of our previous work[7] to a standard environment with a visual interface. Several extensions to the Khoros environment were required to support simulations:

implementation of looping capability and control (if .. then blocks)
implementation of support features to reference sequences of image data
implementation of a "macro" capability to reduce workspace complexity;
implementation of global parameter and variable utilities to allow simulation modules to pass scaler information.

These features have been incorporated in the recently released Khoros 1.0 software[8]. The Khoros user interface can be described as a visual programming language using graphical icons as functional primitives, and structured pipelined data flow as the programming paradigm. This interface is supported with a user interface specification language and graphical interactive interface prototyper, a code and documentation tool set and a large array of image and signal processing routines. The interface provides productivity increasing capability - the interface is consistent across applications, file names are automatically generated, multiple levels of "help" exist, and the system contains integrated 2D and 3D vector graphics packages, and a rich complement of interactive raster display utilities.

The Khoros software is based on the X-11R4 standard and is implemented under the UNIX operating system on a variety of platforms. The simulation or any other application code is developed in a workspace which can be custom configured. Functions are represented as " glyphs" and connections indicate data flow. Dialog boxes support user inputs and selections. Figure 1 shows a Khoros workspace with a simple process which displays an image and a histogram of the image executing.

We have implemented our tracker simulation under the Khoros environment on a SUN 4/470 workstation with color monitor and 32 Mbytes of memory. Both "C" and Fortran functions are incorporated in the simulation. Image data can be acquired by ethernet transfer of digital images obtained from a PC-386 with a frame grabber board and a video optical disk as a programmable analog video mass storage device. We showed that this process can be controlled from within Khoros on a frame by frame basis but we have found it more convenient to digitize a sequence of frames and pass the file to the SUN. The segmenting operation can occur on the PC or the SUN. Figure 2 is a schematic of image data transfer to the workstation.

3. THE SIMULATION APPLICATION

A block diagram of the Khoros glyph structure we have implemented to produce the tracker simulation is shown in Figure 3. At the bottom of this figure the existence of data and temporary files is indicated. The system is designed to be easily modified, with functions being added or subtracted as new algorithms are developed. For example , the segmentation operation is currently performed on a PC/386 using an intelligent region growing algorithm[9]; however unsegmented images could be transferred from the PC and an existing Khoros segmentation algorithm executed (or a new segmenter could be added).

The simulation architecture represents the integration of three major algorithmic steps - segmentation, pattern recognition, and estimation/prediction. Currently these modules are based on the following contributors:

Segmentation: The intelligent region growing algorithm was developed for PC/386 systems at SRE, Inc.[9].

Pattern Recognition: the identify function is based on modules extracted from the VISIX[10] package, and is based on a "standard" moments feature vector[5]. Individual VISIX functions can be incorporated into the simulation by a command line reformatter interface we developed. In addition, data format conversions are available for a wide variety of format types. The segmented image is identified and rotation angles estimated by referencing the extracted feature vector to a database of targets at a selectable range of view angles. Thus the current simulation performs target identification and aspect angle recognition functions. Support functions allow the generation of new target database entries. These functions require a wire grid model of the target. This model is then rotated and projected onto an image plane at the selected view angles, and the computed feature vector is stored in the library.

Tracking algorithms : the tracker modules support two modes of operation. In the first mode, all data is presumed to be pre-computed and the tracker module computes the entire time history of radar and aspect data in one step, producing at the end of this step the error as a function of time. In mode two the tracker processes each set of new information in the simulation loop as shown in figure 2. The tracker module allow selection of a variety of estimator and predictor routines - the user selects the desired routines from the modules forms before executing the simulation. The tracker modules implemented in the simulation were developed at Purdue University and were converted to run under Khoros[11].

4. SUMMARY

We have developed an integrated image processing and tracker performance prediction workstation which has wide applicability to signal processing and simulation problems. This workstation is the result of an integration of a recently developed software executive with a powerful visual user interface (Khoros), and application software from a variety of sources. The workstation is especially adept at integrating such diverse inputs into a modular structure , and the simulation data processing flow can be easily changed to support what-if type analyses. This approach has lead to a number of applications in imaging system simulation and image data processing which bear witness to the flexibility of the system design.

5. ACKNOWLEDGEMENTS

The product of this effort is the result of integrating a variety of software systems.. The Khoros environment was developed by Dr. John Rasure and his team at the University of New Mexico. We appreciate the many discussions and resulting enhancements that were integrated into Khoros based on our requirements. Dr. Dominick Andrisani and Timothy Tao at Purdue provided the tracker modules. Dr. Tony Reeves of Cornell University provided the VISIX target identification routines, and Dr. Shin-Yi Hsu of SRE, Inc. developed the image segmentation code. The considerable effort required to integrate this set of contributions was supported by Dr. Norm Coleman and Dr. Frank Kuhl at ARDEC, Picatinney Arsenal under contract DAAA 21-89-C-0071.

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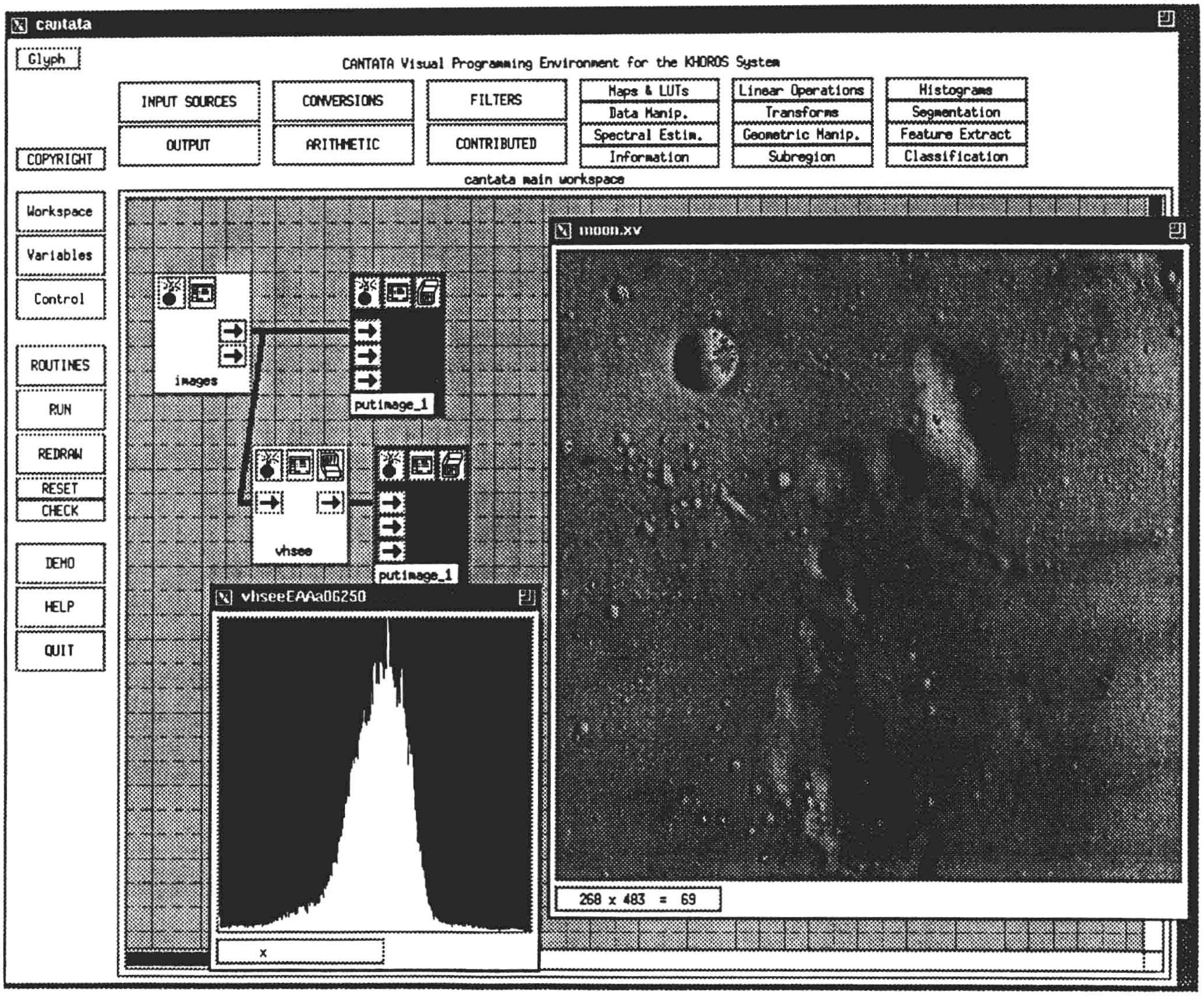

Figure 1. A sample workspace with image display, histogram, and histogram display processes.