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ASRC Aerospace Corp.
Outline

• System Development.
• Performance results compared with existing approaches.
• NASA applications.
• Commercialization.
Soft Computing (SC):

differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation.

provides flexible information processing to handle real life ambiguous situations and achieve tractability, robustness, low solution cost, and close resemblance of human decision making.
System Development

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- **FRED (Fuzzy Reasoning Edge Detection):**
  Image edge extraction technique developed at KSC (patent protected).

- **FRAT (Fuzzy Reasoning Adaptive Thresholding):**
  Image binarization technique developed at KSC (patent protected).

- **Set of Image Enhancement Techniques:**
  Techniques developed at KSC (one patent protected).

- **Visual/Pattern Recognition:**
  Commercially available technique (NeuroShell) via Artificial Neural Network (ANN) and GA (Genetic Algorithm).
Software implementation (Cont).

FRAT algorithm coded in C and “wrapped” under an I/O operator and named KSCThreslin
Performance results compared with existing approaches: FRED

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Original Image: CD containing a hard-to-see major scratch on the center

FRED: The major scratch is clearly shown as well as other minor ones

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Performance results compared with existing approaches: FRED

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Sobel Approach: less clear features, major scratch invisible

Prewit Approach: less clear feature, major scratch invisible
Performance results compared with existing approaches: FRAT

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Original 8-bit Image
Size: 246×245

Then, just a little south and you'll likely of interacting entry in Cha

Otsu’s Method
CPU time: 1.5 ms
Threshold: 88

Huang-Wang Method
CPU time: 10.8 ms
Threshold: 89

Then, just a little south and you'll likely of interacting entry in Cha

New Method
CPU time: 2.0 ms
Threshold: 8

Then, just a little south and you'll likely of interacting entry in Cha

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• *Real-Time (RT) Anomaly Detection.*

• *Real-Time (RT) Moving Debris Detection.*

• *Columbia Investigation.*
RT Anomaly Detection

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- **Image Preprocessing.**
  - Enhancement
  - Segmentation (Binarization)

- **Classification and Learning Processes.**
  - Artificial Neural Network (ANN)
  - Genetic Algorithm (GA)

FRAT
**RT Anomaly Detection**

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Astronauts training on the emergency egress system.

Anomalies on the basket slidewire

- Broken strand.
- Molten spots caused by lighting.
Cable and Line Inspection Mechanism (CLIM)

The National Aeronautics and Space Administration (NASA) seeks to transfer the NASA-developed Cable and Line Inspection Mechanism technology to private industry for use in commercial applications. This mechanism was developed at the John F. Kennedy Space Center (KSC) to provide a means for automated inspection of the seven slidewire cables used in the emergency egress system for the Space Shuttle. There are two sets of gantry cables plus an overhead lightning cable that require periodic inspection. These cables are nonferrous stainless steel; therefore, magnetic cable testers are not suitable for such inspections. Prior to this invention, cable inspections required 150 man-hours twice per year, with inspectors being hoisted in baskets to manually inspect the cables by direct touch and sight. The CLIM technology eliminates the hazardous, manpower-intensive, and time-consuming methods previously required to maintain the emergency egress system at peak performance standards. In addition, CLIM is capable of inspecting the top ends of ferrous wire ropes near the attachment point in the cable housing where magnetic cable testers are unable to reach. CLIM has a further application with respect to radio frequency (RF) tower guy-wire inspections. The low-carbon, low-magnetic inductance of stainless-steel guy-wire cables, combined with added RF radiation interference from the tower, yields magnetic cable testers ineffective. Therefore, CLIM’s ability to conduct a 360-degree view of the cable without incurring RF radiation interference is significant.

CLIM at the lab.

CLIM at the Shuttle Pad

Cable & Line Inspection Mechanism (CLIM) built by NASA.

Slidewire image acquired by CLIM
RT Anomaly Detection (Cont.)

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Blob analysis via ANN-GA engine (input)

Background Extraction + FRED

Binarization via FRAT

Anomaly Detection via ANN-GA engine (output)
RT Anomaly Detection (Cont.)

End-user front end built via MFC.

Main Menu
End-user front end built via MFC.

Training Stage.
Development of classification model via ANN & GA (NeuroShell)
RT Anomaly Detection (Cont.)

Anomaly Detected & displayed in RT.

Firing stage
RT Anomaly Detection (Cont.)

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Original image acquired by CLIM

Automated Region of Interest (ROI) extraction and anomaly detection.
RT Moving FOD Detection

- **Blob Generation (single image)**
  - Segmentation (Binarization)

- **Blob/FOD Selection and Trajectory Computation**
  - Logical path analysis (consecutive images).
RT Moving FOD Detection (Cont.)

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Space Shuttle External Tank.

Tail Service Mask (TSM)

Space Shuttle Tail
RT Moving FOD Detection (Cont.)
RT Moving FOD Detection (Cont.)
Columbia Investigation

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Foam Debris

- **2D: Detection & Location**
  - Segmentation (Binarization)
  - Characterization (center of mass, borders, etc.)

- **3D: Location & Trajectory**
  - Optimal path at three consecutive 3D projections.

FRAT
STS-107 REPORT:

2D-Detection, 3D-Location & 3D-Velocity Estimation of Foam Debris Based on Images acquired by E212 & E208 Video Cameras.

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NASA Kennedy Space Center, June 12, 2003
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Columbia Investigation: Foam Debris Detection/Location (Cont.)

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- E212 at 21.753 s
- ET208 at 21.757 s
- E212 at 21.769 s

Optimized path.
Columbia Investigation:
Foam Debris Detection/Location (Cont.)

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E212 at 21.722 s

ET208 at 21.724 s

E212 at 21.738 s

Optimized path.
Columbia Investigation:
Foam Debris Detection/Location (Cont.)

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E212 at 21.753 s  ET208 at 21.757 s  E212 at 21.769 s

Optimized path.
Debris not detected: Location assumed

- E212 at 21.784 s
- ET208 at 21.791 s
- E212 at 21.800 s

Optimized path.
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**Columbia Investigation:**
**Foam Debris Detection/Location (Cont.)**

Debris not detected: Location assumed

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**Optimized path.**
Columbia Investigation: Foam Debris Trajectory

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Current Work  Lane-Nelson work via LightWave3D

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Columbia Investigation: Foam Debris Trajectory

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Current Work
Lane-Nelson work via LightWave3D

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Columbia Investigation: Foam Debris Velocity

3D Velocity Estimation

- Current Work
- Lane-Nelson Work (via LighWave3D)
Proposed Debris Analysis Software System Development at KSC

VAB Launch Analysis Laboratory at KSC equipped with recently acquired SGI Reality Center facility with a 7-foot display, and advanced SGI TP9500 data management subsystem.

Current OS housing FRAT, FRED, SC-based image pattern recognition.
Commercialization: Licensing

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Patent

NASA

NASA KSC

Technology Marketing

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Commercialization (Cont.)

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Catalog

Figure 9
Commercialization (Cont.)

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http://nasa.rti.org/ksc/imaging

Figure 8
Commercialization (Cont.)

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Commercialization: Status Summary

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- Patents already filed by NASA (February 2004).
- Marketing and Promotion already in place by RTI.
- 2 Software Usage Agreements executed.
- 2 License Agreements executed.
- 3 License Agreements being executed.
- 3 License Agreements in negotiation.