Video Mosaicking for Inspection of Gas Pipelines

This development could lead to automated robotic inspection.

Lyndon B. Johnson Space Center, Houston, Texas

A vision system that includes a specially designed video camera and an image-data-processing computer is under development as a prototype of robotic systems for visual inspection of the interior surfaces of pipes and especially of gas pipelines. The system is capable of providing both forward views and mosaicked radial views that can be displayed in real time or after inspection.

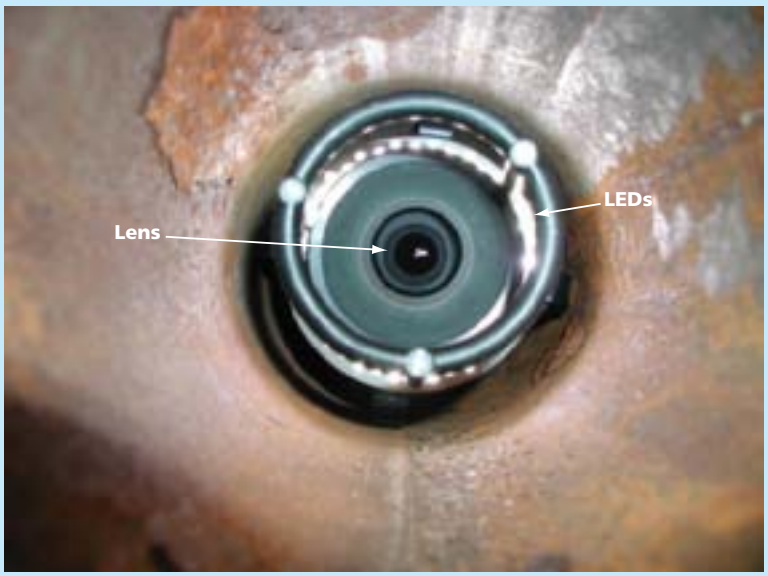
To avoid the complexities associated with moving parts and to provide simultaneous forward and radial views, the video camera is equipped with a wide-angle (>165°) "fish-eye" lens aimed along the axis of a pipe to be inspected. Nine white-light-emitting diodes (LEDs) placed just outside the field of view of the lens (see Figure 1) provide ample diffuse illumination for a high-contrast image of the interior pipe wall.

The video camera contains a 2/3-in. (1.7-cm) charge-coupled-device (CCD) photodetector array and functions according to the National Television Standards Committee (NTSC) standard. The video output of the camera is sent to an off-the-shelf video capture board (frame grabber) by use of a peripheral component interconnect (PCI) interface in the computer, which is of the 400-MHz, Pentium II (or equivalent) class.

Prior video-mosaicking techniques are applicable to narrow-field-of-view (low-distortion) images of evenly illuminated, relatively flat surfaces viewed along approximately perpendicular lines by cameras that do not rotate and that move approximately parallel to the viewed surfaces. One such technique for real-time creation of mosaic images of the ocean floor involves the use of visual correspondences based on area correlation, during both the acquisition of separate images of adjacent areas and the consolidation (equivalently, integration) of the separate images into a mosaic image, in order to insure that there are no gaps in the mosaic image.

The data-processing technique used for mosaicking in the present system also involves area correlation, but with several notable differences: Because the wide-angle lens introduces considerable distortion, the image data must be processed to effectively unwarp the images (see Figure 2). The computer executes special software that includes an unwarping algorithm that takes explicit account of the cylindrical pipe geometry. To reduce the processing time needed for unwarping, parameters of the geometric mapping between the circular view of a fisheye lens and pipe wall are determined in advance from calibration images and compiled into an electronic lookup table. The software incorporates the assumption that the optical axis of the camera is parallel (rather than perpendicular) to the direction of motion of the camera. The software also com-

(a)



(b)

Figure 1. The **Camera Is Aimed Along the Axis** of a pipe, shown in (a) before insertion into the pipe and in (b) inside the pipe. LEDs provide the illumination needed to acquire video images of the inside pipe wall.

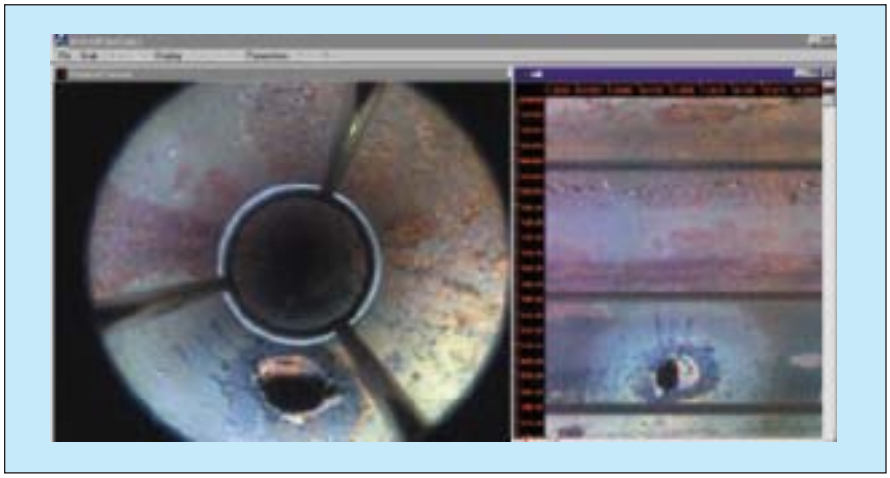


Figure 2. A **Picture Taken Looking Along a Pipe** is distorted (warped) by the combined effects of the lens and the viewing geometry (left). The image data are processed to unwarp the image (right), yielding an undistorted radial view.

pensates for the decrease in illumination with distance from the ring of LEDs.

The potential advantages to be gained from the development of this system are best understood in comparison with visual pipeline-inspection systems in current use. Almost all of those systems offer unprocessed video images for viewing by humans in real time or in post-inspection playback. The fatigue induced by long viewing of mostly featureless images makes such inspection somewhat unreliable, and cost of labor for such inspection is high. If, as planned, the present system could be enhanced by use of additional computer vision techniques, then visual inspection of pipelines could be promoted to supervised inspection, which, in turn, could be a precursor to partly or totally automated inspection. According to one scenario, a system derived from the present one would provide enhanced graphical displays, possibly with highlights on potential defects, and could even provide audible alarms to alert operators. Operators could then concentrate their attention on pipeline sections most likely to contain defects. Reliability of pipeline inspection would thus be increased and the cost of labor reduced.

This work was done by Darby Magruder of **Johnson Space Center** *and Chiun-Hong Chien of Hernandez Engineering. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.*
MSC-23075

Shuttle-Data-Tape XML Translator

Lyndon B. Johnson Space Center, Houston, Texas

JSDTImport is a computer program for translating native Shuttle Data Tape (SDT) files from American Standard Code for Information Interchange (ASCII) format into databases in other formats. JSDTImport solves the problem of organizing the SDT content, affording flexibility to enable users to choose how to store the information in a database to better support client and server applications. JSDTImport can be dynamically configured by use of a simple Extensible Markup Language (XML) file. JSDTImport uses this XML file to define how each record and field will be parsed, its layout and definition, and how the resulting database will be structured. JSDTImport also includes a client application programming interface (API) layer that provides abstraction for the data-querying process. The API enables a user to specify the search criteria to apply in gathering all the data relevant to a query. The API can be used to organize the SDT content and translate into a native XML database. The XML format is structured into efficient sections, enabling excellent query performance by use of the XPath query language. Optionally, the content can be translated into a Structured Query Language (SQL) database for fast, reliable SQL queries on standard database server computers.

This program was written by Matthew R. Barry and Richard N. Osborne of United Space Alliance for **Johnson Space Center**. *For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.*
MSC-23579

Highly Reliable, High-Speed, Unidirectional Serial Data Links

Forward error correction would afford reliability in the absence of retransmission.

Lyndon B. Johnson Space Center, Houston, Texas

Highly reliable, high-speed, unidirectional serial data-communication subsystems have been proposed to be installed in an upgrade of the computing systems aboard the space shuttles. The basic design concept of these serial data links is also adaptable to terrestrial use in applications in which there are requirements for highly reliable serial data communications.

The hardware and software aspects of the architecture of the data links are dictated largely by a requirement, in the original space-shuttle application, for one computer to monitor the memory transactions and memory contents of other computers in real time with high reliability and without reliance on requests for retransmission. To minimize weight while affording a capability to transfer data at a required rate of 2.56×10^8 bits per second, it was decided that the links would be serial ones of the fiber-channel type. ["Fiber channel" denotes a type of serial computer bus that is used to connect a computer (usually a supercomputer) with a high-speed data-storage device. Depending on the spe-