USER STORY

Camera-in-a-Capsule Developed in MATLAB® Improves the Diagnosis of Gastrointestinal Disorders

Every year, diseases of the gastrointestinal (GI) tract account for more than 30 million office visits in the United States alone.

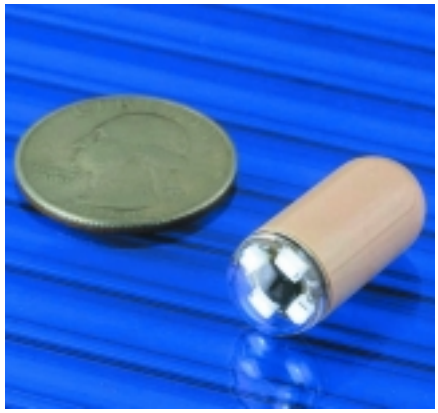
GI tract disorders are easy to cure in their early stages but are difficult to diagnose: Common test procedures, such as endoscopy, are unreliable and can be so painful or invasive that patients often avoid showing up for the exam.

The Israeli biomedical company, Given Imaging, has developed M2A™, a minimally invasive diagnostic tool that substantially improves visual imaging of the small intestine. It consists of a tiny video camera in a swallowable capsule. The camera transmits digital pictures from the GI tract to a receiver fitted against the patient's body. The resulting pictures are processed and can then be sent electronically to an attending physician anywhere in the world.

Given Imaging relied on MATLAB® and other MathWorks tools throughout the development of M2A™. According to Dr. Arkady Glukhovsky, vice president of R&D at Given Imaging, "MATLAB is essential for any developer who writes algorithms, tests and checks systems, and plans and builds technically complex prototypes."

THE CHALLENGE

The inventor of the capsule, Dr. Gabriel Iddan, set out to develop an imaging technique that would enable examination of the small intestine without subjecting the patient to pain or discomfort. A former senior engineer at Rafael, the R&D group of the Israeli Ministry of Defense, Dr. Iddan derived the capsule concept from a defense project involving the development of electro-optical devices for missiles.



The M2A™ capsule, shown next to a US quarter.

The disposable M2A™ capsule contains a miniaturized color video camera, a miniature battery, an antenna, and a radio transmitter. The images of the small intestine, captured by the camera at a rate of about two per second, are transmitted by radio frequency to an array of sensors on a waist-belt worn by the patient.

Approximately eight hours and 50,000 images later, the patient returns the belt and recorder to the clinic. Here, the images are downloaded onto a computer workstation equipped with Given's proprietary RAPID™ (Reporting and Processing of Images and Data) software. This software processes the data and produces a 20-minute video of the images transmitted by the capsule as it passed through the GI tract. The doctor can then scan the video for abnormalities.

The Given Imaging team needed tools that would enable them to evaluate different algorithms quickly and efficiently.

THE CHALLENGE

To find an alternative to the endoscope and other invasive gastrointestinal imaging procedures

THE SOLUTION

Use MATLAB and MATLAB toolboxes to implement and develop an alternative diagnostic tool

THE RESULTS

- Fast, efficient development
- Easy access to precise diagnostic information
- Improved patient care

> *MATLAB and the MATLAB Image Processing Toolbox enabled us to cut down development time by several orders of magnitude. Without these tools, it is hard for me to believe that we could have completed development of this complexity in such a short time frame. We met our goals and astounded even those who had believed we would succeed.*
>
> Dr. Arkady Glukhovsky, Given Imaging

THE SOLUTION

Dr. Glukhovsky and his colleagues selected MATLAB and the Image and Signal Processing Toolboxes because they provided an environment that enabled precise, convenient, and most important, rapid development.

They used MATLAB to develop and verify algorithms that decoded the information transmitted over the recorder and processed the images. They also used the MATLAB fast Fourier analysis functions. Throughout the development process, they relied heavily on the data visualization capabilities in MATLAB, specifically, MATLAB functions for creating contour plots, line plots, and histograms.

The Image Processing Toolbox was used for the feasibility study, development, and refinement phases of the image processing project. The toolbox is still being used to develop new image processing features and capabilities. In addition, the team relied on several capabilities in the Signal Processing Toolbox, including localization, to refine design parameters for visual comparison and for preliminary visualization of algorithm results.

The team determined that without the contour and 3D plots and other display functions provided in MATLAB and the toolboxes, the project would have been difficult to accomplish.

M2A™ has been tested on over 20 human volunteers. None of the subjects complained of discomfort, and physicians report that the capsule produces excellent images of the small intestine. FDA approval is expected during the third quarter of 2001.

Given Imaging continues to use MATLAB for image enhancement and image segmentation and classification, as well as for developing future versions of the capsule.

THE RESULTS

- **Fast, efficient development.** Working in MATLAB, Given Imaging executed elaborate analyses and reached a product model in a matter of months.
- **Easy access to precise diagnostic information.** The capsule provides several types of information simultaneously, including the timing of the digestive process in the patient and the presence of minute abnormalities. "The camera can detect the shape and precise location of a polyp smaller than one-tenth of a millimeter," says Dr. Glukhovsky. "This cannot be done by endoscopy, and it's hard to see a polyp smaller than five millimeters on an X-ray."
- **Improved patient care.** M2A™ enables diagnosis of areas of the small intestine which are unreachable with standard imaging methods. Patient management and care will change as a result.

To find out more about Given Imaging visit **www.givenimaging.com**

APPLICATION AREAS

- Image processing
- Biomedical engineering
- R&D

PRODUCTS USED

- MATLAB®
- Image Processing Toolbox
- Signal Processing Toolbox

www.mathworks.com

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