tance Gaussian is applied (to bring out the stronger corners), and then each value in the entire window is summed and stored. The required components of the equation are in place, and it is just a matter of taking the determinant and trace. It should be noted that the trace is being weighted by a constant κ, a value that is found empirically to be within 0.04 to 0.15 (and in this implementation is 0.05). The constant κ determines the number of corners available to be compared against a threshold σ to mark a "valid corner."

After a fixed delay from when the first pixel is clocked in (to fill the pipeline), a score is achieved after each successive clock. This score corresponds with an (x, y) location within the image. If the score is higher than the predetermined threshold σ, then a flag is set high and the location is recorded.

This work was done by Arin C. Morfopoulos and Brandon C. Metz of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47202

Special Component Designs for Differential-Amplifier MMICs
Transistors and transmission lines are optimized for differential operation.

NASA's Jet Propulsion Laboratory, Pasadena, California

Special designs of two types of electronic components — transistors and transmission lines — have been conceived to optimize the performances of these components as parts of waveguide-embedded differential-amplifier monolithic microwave integrated circuits (MMICs) of the type described in the immediately preceding article. These designs address the following two issues, the combination of which is unique to these particular MMICs:

• Each MMIC includes a differential double-strip transmission line that typically has an impedance between 60 and 100 W. However, for purposes of matching of impedances, transmission lines having lower impedances are also needed.

• The transistors in each MMIC are, more specifically, one or more pair(s) of InP-based high-electron-mobility transistors (HEMTs). Heretofore, it has been common practice to fabricate each such pair as a single device configured in the side-to-side electrode sequence source/gate/drain/gate/source. This configuration enables low-inductance source grounding from the sides of the device. However, this configuration is not suitable for differential operation, in which it is necessary to drive the gates differentially and to feed the output from the drain electrodes differentially.

The special transmission-line design provides for three conductors, instead of two, in places where lower impedance is needed. The third conductor is a metal strip placed underneath the differential double-strip transmission line. The third conductor increases the capacitance per unit length of the transmission line by such an amount as to reduce the impedance to between 5 and 15 W.

In the special HEMT-pair design, the side-to-side electrode sequence is changed to drain/gate/source/gate/drain. In addition, the size of the source is reduced significantly, relative to corresponding sizes in prior designs. This reduction is justified by the fact that, by virtue of the differential configuration, the device has an internal virtual ground, and therefore there is no need for a low-resistance contact between the source and the radio-frequency circuitry.

The source contact is needed only for DC biasing.

These designs were implemented in a single-stage-amplifier MMIC. In a test at a frequency of 305 GHz, the amplifier embedded in a waveguide exhibited a gain of 0 dB; after correcting for the loss in the waveguide, the amplifier was found to afford a gain of 0.9 dB. In a test at 220 GHz, the overall gain of the amplifier-and-waveguide assembly was found to be 3.5 dB.

This work was done by Pekka Kangaslahti of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-44393, volume and number of this NASA Tech Briefs *issue, and the page number.*

Multi-Stage System for Automatic Target Recognition
## This system is capable of identifying hazards to avoid in robotic vehicle and automobile navigation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A multi-stage automated target recognition (ATR) system has been designed to perform computer vision tasks with adequate proficiency in mimicking human vision. The system is able to detect, identify, and track targets of interest. Potential regions of interest (ROIs) are first identi-fied by the detection stage using an Optimum Trade-off Maximum Average Correlation Height (OT-MACH) filter combined with a wavelet transform. False positives are then eliminated by the verification stage using feature extraction methods in conjunction with neural networks. Feature extraction transforms the ROIs using filtering and binning algorithms to create feature vectors. A feed-forward back-propagation neural network (NN) is then trained to classify each feature vector and to remove false positives. The system parameter optimiza-
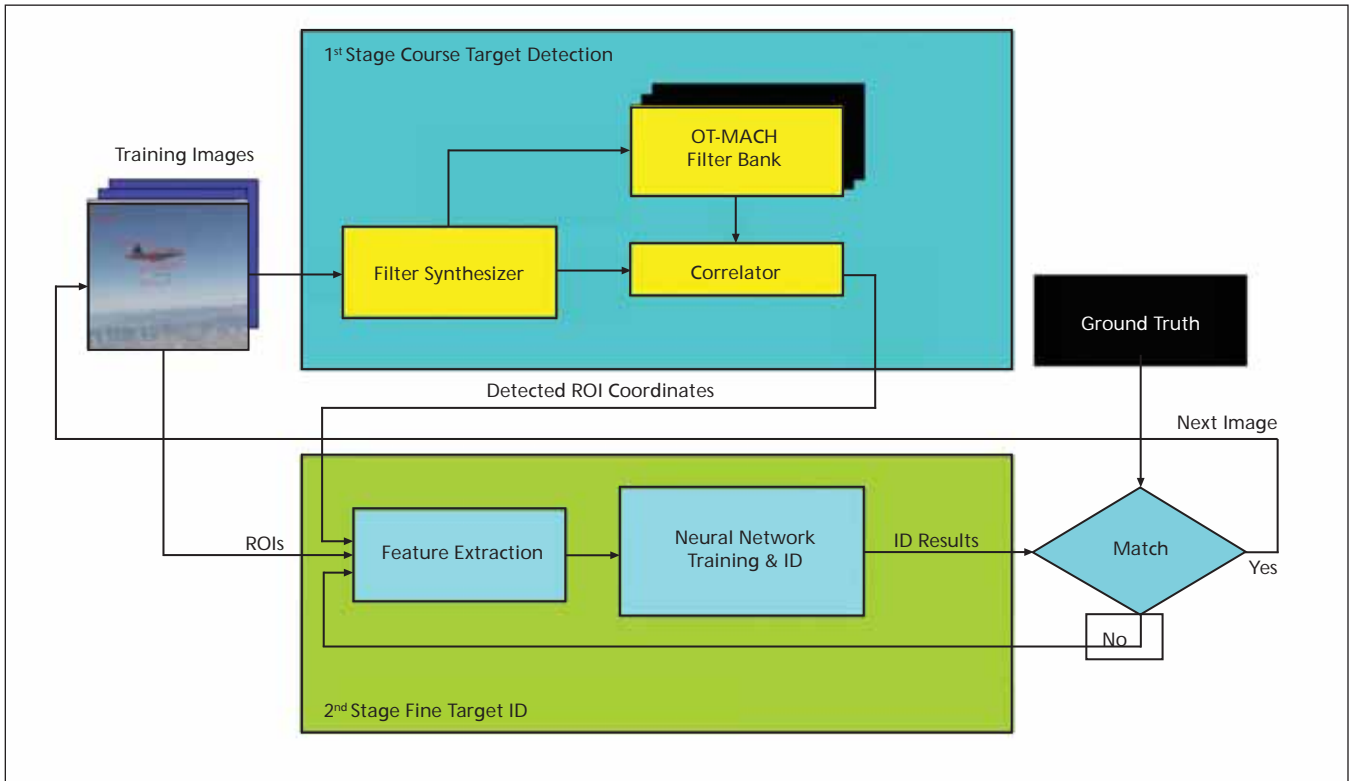
The **Multi-Stage ATR System Architecture** incorporates a detection stage that first identifies potential ROIs where the target may be present by performing a Fast Fourier domain OT-MACH filter-based correlation.

tions process has been developed to adapt to various targets and datasets.

The objective was to design an efficient computer vision system that can learn to detect multiple targets in large images with unknown backgrounds. Because the target size is small relative to the image size in this problem, there are many regions of the image that could potentially contain the target. A cursory analysis of every region can be computationally efficient, but may yield too many false positives. On the other hand, a detailed analysis of every region can yield better results, but may be computationally inefficient. The multi-stage ATR system was designed to achieve an optimal balance between

accuracy and computational efficiency by incorporating both models.

The detection stage first identifies potential ROIs where the target may be present by performing a fast Fourier domain OT-MACH filter-based correlation. Because threshold for this stage is chosen with the goal of detecting all true positives, a number of false positives are also detected as ROIs. The verification stage then transforms the regions of interest into feature space, and eliminates false positives using an artificial neural network classifier.

The multi-stage system allows tuning the detection sensitivity and the identification specificity individually in each

stage. It is easier to achieve optimized ATR operation based on its specific goal. The test results show that the system was successful in substantially reducing the false positive rate when tested on a sonar and video image datasets.

Single-Receiver GPS Phase Bias Resolution

NASA's Jet Propulsion Laboratory, Pasadena, California

Existing software has been modified to yield the benefits of integer fixed double-differenced GPS-phased ambiguities when processing data from a single GPS receiver with no access to any other GPS receiver data. When the double-differenced combination of phase biases can be fixed reliably, a sig-

nificant improvement in solution accuracy is obtained.

This innovation uses a large global set of GPS receivers (40 to 80 receivers) to solve for the GPS satellite orbits and clocks (along with any other parameters). In this process, integer ambiguities are fixed and information on the ambi-

guity constraints is saved. For each GPS transmitter/receiver pair, the process saves the arc start and stop times, the wide-lane average value for the arc, the standard deviation of the wide lane, and the dual-frequency phase bias after bias fixing for the arc. The second step of the process uses the orbit and clock infor-