IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS

Image Processing Technologies, LLC Plaintiff, v. Samsung Electronics Co., Ltd and Samsung Electronics America, Inc. Defendant.	Civil Action No. 2:16-CV-505-JRG

DECLARATION OF GERARD P. GRENIER

I, Gerard P. Grenier, am over twenty-one (21) years of age. I have never been convicted of a felony, and I am fully competent to make this declaration.

1. I am Senior Director of Publishing Technologies of the Institute of Electrical and Electronics Engineers, Inc. ("IEEE"). My office address is 445 Hoes Lane Piscataway, NJ 08854.

2. Among my responsibilities as Senior Director of Publishing Technologies, I act as a custodian of certain records for IEEE.

3. IEEE received a Subpoena, dated November 10, 2016 in the above-captioned case, requesting the production of documents sufficient to show the date certain articles, which are identified below, were first published, sold, or otherwise made available to the public.

4. In response to that Subpoena, I make this declaration on behalf of the IEEE based on my personal knowledge and information contained in the business records of IEEE. It is the regular practice of IEEE to publish articles and other writings, including article abstracts, and make them available to the public through IEEE Xplore, an on-line digital library. IEEE maintains copies of publications in the ordinary course of its regularly conducted activities.

5. The following articles, accompanied by their abstracts, have been attached as Exhibits to this declaration:

A	Alton L. Gilbert, et al., "A Real-Time Video Tracking System"

B	O.D. Altan, H.K. Patnaik, and R.P. Roesser, "Computer Architecture and Implementation of Vision-Based Real-Time Lane Sensing"

6. I obtained copies of each of the attached Exhibits through IEEE Xplore, where they are maintained in the ordinary course of the IEEE's business. Each Exhibit is a true and correct copy of the Exhibit as it existed on or about November 16, 2016.

7. The attached Exhibits include a date of publication and the manner in which the publication was published. IEEE Xplore populates this information using the metadata associate with the publication. Based on IEEE's regular business practices, the date of publication identified in the abstract is the date when IEEE first made the article available to the public, first offered the article for sale in the United States, and/or first published the article.

Pursuant to Section 1746 of Title 28 of the United States Code, I declare under penalty of perjury that the foregoing is true and correct to the best of my personal knowledge or information

Executed on the 2nd day of November, 2016.

By: ______________________

Gerard P. Grenier

Exhibit A

A Real-Time Video Tracking System

ALTON L. GILBERT, MEMBER, IEEE, MICHAEL K. GILES, GERALD M. FLACHS, MEMBER, IEEE, ROBERT B. ROGERS, MEMBER, IEEE, AND YEE HSUN U, MEMBER, IEEE

Abstract—Object identification and tracking applications of pattern recognition at video rates is a problem of wide interest, with previous attempts limited to very simple threshold or correlation (restricted window) methods. New high-speed algorithms together with fast digital hardware have produced a system for missile and aircraft identification and tracking that possesses a degree of "intelligence" not previously implemented in a real-time tracking system. Adaptive statistical clustering and projection-based classification algorithms are applied in real time to identify and track objects that change in appearance through complex and nonstationary background/foreground situations. Fast estimation and prediction algorithms combine linear and quadratic estimators to provide speed and sensitivity. Weights are determined to provide a measure of confidence in the data and resulting decisions. Strategies based on maximizing the probability of maintaining track are developed. This paper emphasizes the theoretical aspects of the system and discusses the techniques used to achieve real-time implementation.

Index Terms—Image processing, intensity histograms, object identification, optical tracking, projections, tracking system, video data compression, video processing, video tracking.

Introduction

IMAGE PROCESSING methods constrained to operate on sequential images at a high repetition rate are few. Pattern recognition techniques are generally quite complex, requiring a great deal of computation to yield an acceptable classification. Many problems exist, however, where such a time-consuming technique is unacceptable. Reasonably complex operations can be performed on wide-band data in real time, yielding solutions to difficult problems in object identification and tracking.

The requirement to replace film as a recording medium to obtain a real-time location of an object in the field-of-view (FOV) of a long focal length theodolite gave rise to the development of the real-time videotheodolite (RTV). U.S. Army White Sands Missile Range began the development of the RTV in 1974, and the system is being deployed at this time. Design philosophy called for a system capable of discriminatory judgment in identifying the object to be tracked with 60 independent observations/s, capable of locating the center of mass of the object projection on the image plane within about 2 percent of the FOV in rapidly changing background/foreground situations (therefore adaptive), able to generate a predicted observation angle for the next observation, and required to output the angular displacements of the object within the FOV within 20 ms after the observation was made. The system would be required to acquire objects entering the FOV that had been prespecified by shape description. In the RTV these requirements have been met, resulting in a real-time application of pattern recognition/image processing technology.

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A. L. Gilbert and M. K. Giles are with the U.S. Army White Sands Missile Range, White Sands, NM 88002.
G. M. Flachs and R. B. Rogers are with the Department of Electrical Engineering, New Mexico State University, Las Cruces, NM 88003.
Y. H. U was with the Department of Electrical Engineering, New Mexico State University, Las Cruces, NM 88003. He is now with Texas Instruments Incorporated, Dallas, TX 75222.

The RTV is made up of many subsystems, some of which are generally not of interest to the intended audience of this paper. These subsystems (see Fig. 1) are as follows:

1) main optics;
2) optical mount;
3) interface optics and imaging subsystem;
4) control processor;
5) tracker processor;
6) projection processor;
7) video processor;
8) input/output (I/O) processor;
9) test subsystem;
10) archival storage subsystem;
11) communications interface.

The *main optics* is a high quality cinetheodolite used for obtaining extremely accurate (rms error $\simeq$ 3 arc-seconds) angular data on the position of an object in the FOV. It is positioned by the *optical mount* which responds to azimuthal and elevation drive commands, either manually or from an external source. The *interface optics and imaging subsystem* provides a capability to increase or decrease the imaged object size on the face of the silicon target vidicon through a 10:1 range, provides electronic rotation to establish a desired object orientation, performs an autofocus function, and uses a gated image intensifier to amplify the image and "freeze" the motion in the FOV. The camera output is statistically decomposed into background, foreground, target, and plume regions by the *video processor*, with this operation carried on at video rates for up to the full frame. The *projection processor* then analyzes the structure of the target regions to verify that the object selected as "target" meets the stored (adaptive) description of the object being tracked. The *tracker processor* determines a position in the FOV and a measured orientation of the target, and decides what level of confidence it has in the data and decision. The *control processor* then generates commands to orient the mount, control the interface optics, and provide real-time data output. An *I/O pro-*

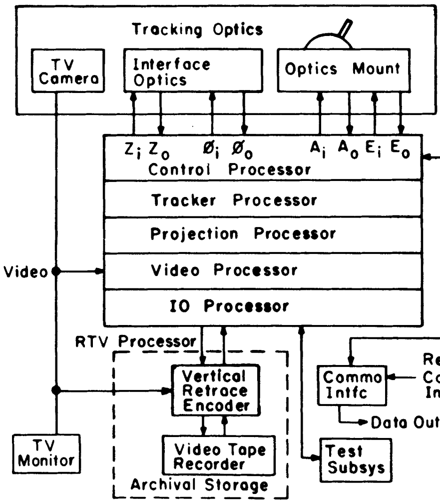

Fig. 1. RTV tracking system.

cessor allows the algorithms in the system to be changed, interfaces with a human operator for tests and operation, and provides data to and accepts data from the *archival storage subsystem* where the live video is combined with status and position data on a video tape. The *test subsystem* performs standard maintenance checks on the system. The *communications interface* provides the necessary interaction with the external world for outputing or receiving data.

The *video processor*, *projection processor*, *tracker processor*, and *control processor* are four microprogrammable bit-slice microprocessors [1], which utilize Texas Instruments' (TIs') new 74S481 Schottky processor, and are used to perform the real-time tracking function.

The four tracking processors, in turn, separate the target image from the background, locate and describe the target image shape, establish an intelligent tracking strategy, and generate the camera pointing signals to form a fully automatic tracking system.

Various reports and papers discuss several of the developmental steps and historical aspects of this project [2]-[7]. In this paper the video, projection, tracker, and control processors are discussed at some length.

Video Processor

The video processor receives the digitized video, statistically analyzes the target and background intensity distributions, and decides whether a given pixel is background or target [8]. A real-time adaptive statistical clustering algorithm is used to separate the target image from the background scene at standard video rates. The scene in the FOV of the TV camera is digitized to form an $n \times m$ matrix representation

$$P = (p_{ij})\, n, m$$

of the pixel intensities p_{ij}. As the TV camera scans the scene, the video signal is digitized at m equally spaced points across each horizontal scan. During each video field, there are n horizontal scans which generate an $n \times m$ discrete matrix representation at 60 fields/s. A resolution of $m = 512$ pixels per standard TV line results in a pixel rate of 96 ns per pixel.

eight bits (256 gray levels), counted into one of six 256-level histogram memories, and then converted by a decision memory to a 2-bit code indicating its classification (target, plume, or background). There are many features that can be functionally derived from relationships between pixels, e.g., texture, edge, and linearity measures. Throughout the following discussion of the clustering algorithm, pixel intensity is used to describe the pixel features chosen.

The basic assumption of the clustering algorithm is that the target image has some video intensities not contained in the immediate background. A tracking window is placed about the target image, as shown in Fig. 2, to sample the background intensities immediately adjacent to the target image. The background sample should be taken relatively close to the target image, and it must be of sufficient size to accurately characterize the background intensity distribution in the vicinity of the target. The tracking window also serves as a spatial bandpass filter by restricting the target search region to the immediate vicinity of the target. Although one tracking window is satisfactory for tracking missile targets with plumes, two windows are used to provide additional reliability and flexibility for independently tracking a target and plume, or two targets. Having two independent windows allows each to be optimally configured and provides reliable tracking when either window can track.

The tracking window frame is partitioned into a background region (BR) and a plume region (PR). The region inside the frame is called the target region (TR) as shown in Fig. 2. During each field, the feature histograms are accumulated for the three regions of each tracking window.

The feature histogram of a region R is an integer-value, integer argument function $h^R(x)$. The domain of $h^R(x)$ is $[0, d]$, where d corresponds to the dynamic range of the analog-to-digital converter, and the range of $h^R(x)$ is $[0, r]$, where r is the number of pixels contained in the region R; thus, there are $r + 1$ possible values of $h^R(x)$. Since the domain $h^R(x)$ is a subset of the integers, it is convenient to define $h^R(x)$ as a one-dimensional array of integers

$$h(0), h(1), h(2), \cdots, h(d).$$

Letting x_i denote the ith element in the domain of x (e.g., $x_{25} = 24$), and $x(j)$ denote the jth sample in the region R (taken in any order), $h^R(x)$ may be generated by the sum

$$h^R(x_i) = \sum_{j=1}^{r} \delta x_i, x(j)$$

where δ is the Kronecker delta function

$$\delta_{i,j} = \begin{cases} 0 & i \neq j \\ 1 & i = j. \end{cases}$$

A more straightforward definition which corresponds to the actual method used to obtain $h^R(x)$ uses Iverson's notation [21] to express $h^R(x)$ as a one-dimensional vector of $d + 1$ integers which are set to zero prior to processing the region R as

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