08/

Class	Subclass

ISSUE CLASSIFICATION

[redacted]

UTILITY SERIAL NUMBER 08/ 274394	PATENT DATE	PATENT NUMBER

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
08/274,394	07/11/94	~~375~~ 364	429	2614 2304	Nguyen

APPLICANTS: JED MARGOLIN, SAN JOSE, CA.

CONTINUING DATA*******************
VERIFIED
TN

FOREIGN/PCT APPLICATIONS**********
VERIFIED
TN

***** SMALL ENTITY *****

Foreign priority claimed ☐ yes ☒ no 35 USC 119 conditions met ☐ yes ☒ no Verified and Acknowledged ___ Examiner's Initials	AS FILED →	STATE OR COUNTRY	SHEETS DRWGS.	TOTAL CLAIMS	INDEP. CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
		CA	13	13	3	$355.00	

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Keith D. Askoff
Blakely, Sokoloff, Taylor & Zafman
12400 Wilshire Boulevard, 7th floor
Los Angeles CA. 90025

TITLE: PILOT AID USING A SYNTHETIC-~~REALITY~~ Environment

U.S. DEPT. of COMM.-Pat. & TM Office—PTO-436L (rev. 10-

PARTS OF APPLICATION FILED SEPARATELY

Applications Examiner

NOTICE OF ALLOWANCE MAILED

Assistant Examiner

CLAIMS ALLOWED

Total Claims	Print Claim

ISSUE FEE

Amount Due	Date Paid

DRAWING

Sheets Drwg.	Figs. Drwg.	Print Fig.

Primary Examiner

ISSUE BATCH NUMBER

PREPARED FOR ISSUE

Label Area

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Form PTO-436A
(Rev. 8/92)

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INITIALS ____________

CONTENTS

RECEIVED SEP 27 1994 GROUP 2300

PAT & T.M. OFFICE MAILED SEP 14 1994 LICENSING & REVIEW

Date Entered or Counted			Date Received or Mailed
	1.	Application papers.	
10/12-94	2.	PRIOR ART	7-11-94
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Class	Sub.	Date	Exmr.
364	449 444 448 459 460 462	11/03/94	TN
340	961 967 974 980 990 995	11/04/94	TN
342	29 450 451 463		
395	101		
update search to above		05/04/95	TN

35

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.

SEARCH NOTES

	Date	Exmr.
APS search	11/06/94	TN

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                ACT POLYGON/L
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L1   (          1)SEA FILE=USPAT PLU=ON  5005148/PN AND POLYGON
L2   (         27)SEA FILE=USPAT PLU=ON  POLYGON (10A) DATA BASE
L3   (          2)SEA FILE=USPAT PLU=ON  TERRAIN (P) MANMADE (5A) STRU
L4   (          0)SEA FILE=USPAT PLU=ON  L2 AND L3
L5   (         10)SEA FILE=USPAT PLU=ON  L2 AND AIRCRAFT
L6   (          8)SEA FILE=USPAT PLU=ON  L5 AND (TERRAIN OR MANMADE) (
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L7   (          8)SEA FILE=USPAT PLU=ON  L5 AND (TERRAIN OR MANMADE (0
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L8   (         44)SEA FILE=USPAT PLU=ON  POLYGON (P) (TERRAIN OR MANMA
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L9   (         30)SEA FILE=USPAT PLU=ON  L8 AND AIRCRAFT AND DATA BASE
L10  (          1)SEA FILE=USPAT PLU=ON  L9 AND ALTITUDE AND ORIENT
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L1   (        296)SEA FILE=USPAT PLU=ON  (AIRCRAFT OR CRAFT) AND DISP
AND
L2   (        896)SEA FILE=USPAT PLU=ON  AVOINIC OR GYROCOMPASS OR TU
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L3   (         26)SEA FILE=USPAT PLU=ON  DIGITAL (8A) DATA BASE AND D
L4   (          6)SEA FILE=USPAT PLU=ON  TERRAIN AND MANMADE (5A) STR
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L6   (        200)SEA FILE=USPAT PLU=ON  VISUAL FLIGHT RULE OR VFR
L7   (        199)SEA FILE=USPAT PLU=ON  INSTRUMENT FLIGHT RULE OR IF
L8   (       6108)SEA FILE=USPAT PLU=ON  THREE (8A) DIMENSION### (P)
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L9   (      73697)SEA FILE=USPAT PLU=ON  (PAN### OR TILT### OR ZOOM O
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L11  (         46)SEA FILE=USPAT PLU=ON  L6 AND L7
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	Date	Exmr.
APS search	05/04/95	TN

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     (FILE 'USPAT' ENTERED AT 09:29:55 ON 04 MAY 95)
L1             49 S TERRAIN (P) POLYGON
L2             27 S L1 AND AIRCRAFT
L3             23 S L2 AND ((THREE OR 3) (10A) (DIMENSION### OR D))
L4            201 S ELEVAT### (20A) DATA (L) TERRAIN
L5              0 S L3 AND L14
L6             12 S L1 AND ELEVATION
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01402

1-7-93

PATENT APPLICATION FEE DETERMINATION RECORD

Effective October 1, 1992

Application or Docket Number: 08/224394

CLAIMS AS FILED - PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE	SMALL ENTITY FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY FEE
BASIC FEE				$355.00	OR		$710.00
TOTAL CLAIMS	13 minus 20 =	* —	x$11=		OR	x$22=	
INDEPENDENT CLAIMS	3 minus 3 =	*	x 37=		OR	x 74=	
MULTIPLE DEPENDENT CLAIM PRESENT			+115=		OR	+230=	
			TOTAL	355	OR	TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

AMENDMENT A

A	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	* 39	Minus	** 20	= 19	x$11=	209	OR	x$22=	
Independent	* 5	Minus	*** 3	= 1	x 37=	76	OR	x 74=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+ 115=		OR	+230=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

B	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	* 37	Minus	** 37	=	x$11=		OR	x$22=	
Independent	* 4	Minus	*** 5	=	x 37=		OR	x 74=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+ 115=		OR	+ 230=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	x$11=		OR	x$22=	
Independent	*	Minus	***	=	x 37=		OR	x 74=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+115=		OR	+230=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875
(Rev.10-92)

Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Form PTO 1130
(REV 2/94)

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

PACE DATA ENTRY CODING SHEET

1ST EXAMINER	49	DATE	8-10-94
2ND EXAMINER		DATE	

APPLICATION NUMBER	TYPE APPL	FILING DATE (MONTH DAY YEAR)	SPECIAL HANDLING	GROUP ART UNIT	CLASS	SHEETS OF DRAWING
274394	1	07 11 94		2614	375	-13

TOTAL CLAIMS	INDEPENDENT CLAIMS	SMALL ENTITY?	FILING FEE	FOREIGN LICENSE	ATTORNEY DOCKET NUMBER
-13	--3	1	-355	N	

CONTINUITY DATA

CONT CODE	STATUS CODE	PARENT APPLICATION SERIAL NUMBER	PCT APPLICATION SERIAL NUMBER	PARENT PATENT NUMBER	PARENT FILING DATE (MONTH DAY YEAR)
			PCT/ /		
			PCT/ /		
			PCT/ /		
			PCT/ /		
			PCT/ /		

PCT/FOREIGN APPLICATION DATA

FOREIGN PRIORITY CLAIMED	COUNTRY CODE	PCT/FOREIGN APPLICATION SERIAL NUMBER	FOREIGN FILING DATE (MONTH DAY YEAR)

01404

TITLE OF INVENTION

ATTORNEY REGISTRATION NUMBERS

CORRESPONDENCE NAME AND ADDRESS

APPLICANT/INVENTOR DATA

AUTHORITY CODE

FAMILY NAME

NAME SUFFIX

GIVEN NAME

STATE/CTRY CODE

CITY

AUTHORITY CODE

FAMILY NAME

NAME SUFFIX

GIVEN NAME

STATE/CTRY CODE

CITY

01405

provide a high-level, device-independent communication layer between the user subsystems and the ITARS hardware. These routines properly construct ITARS messages from the values specified in their input arguments and send the messages to the Brass Board process. In addition, these routines asynchronously receive data from the Brass Board process, and double-buffer it for later use by the user subsystem.

To accelerate the integration effort, Merit Technology created a program know as the ITARS Emulator. This program coexisted on the microVAX with the other user subsystems and provided terrain elevation data (at a reduced resolution) in a message format defined in the ITARS ICD. The Emulator also received aircraft state vectors, point Feature messages and user request messages sent by the aircraft model and main RDS task. Like the Brass Board process, each user subsystem communicated with the ITARS Emulator through the IDIR software. The Emulator proved to be an invaluable tool for system debugging and led to a significant change in the integration plan.

The original integration plan defined the IDIR as the final layer between the user subsystems and the RDS/ITARS communication hardware. The plan called for rewriting the IDIR software to communicate directly with the ITARS. This was determined to be a significant effort because the original IDIR software used DECNET for all of its interhost communication. The RDS/ITARS IDIR software would also need functionality similar to DECNET. The idea arose to add Ethernet and 1553 interfaces to the ITARS Emulator and forward messages "through" the Emulator to the ITARS hardware, hence the Brass Board process was born. An early version of the Brass Board process was an ITARS Emulator with a 1553 interface forwarding messages to the ITARS. This configuration provided a needed incremental integration step and allowed the RDS to operate without an Ethernet link from the ITARS (terrain data was generated by the Emulator). Later versions eliminated the ITARS Emulation logic and included an Ethernet interface. The advantage of this layered approach preserved the DECNET IDIR interface, eliminating any code changes to the user subsystems. Indeed, the user subsystems are "unaware" of the source of their elevation data.

Results of system integration

During integration several key lessons were learned about the RDS. As the system neared completion, it became apparent that limitations existed in the area of software partitioning. Although it is possible to host each subsystem in any machine, the configuration shown in Figure 2 proved to be optimal due to the through put requirements of each algorithm. The TA/ThA algorithm combined with the flight model, route planner, and main RDS task consume all of the processing capability of the first microVAX (the route planner executes before the flight simulation and therefore does not contend with TA/ThA). Analysis has shown that the bulk of processing on this microVAX is credited to the TA/ThA algorithm. The TF, SITAN and communication software load the second microVAX to 88.0 percent of its capability. If the ITARS Emulator is used instead of the Brass Board process, the microVAX becomes fully loaded. Based upon these estimates, the RDS fully loads both microVAX systems. Full real-time execution speed is achievable in a TF only configuration, however, with the addition of a third microVAX, full real-time execution speed could be achieved in a full-up configuration.

A larger than expected reduction in system throughput was noticed when the ITARS message monitoring mechanism was integrated into the system. This can be explained as follows: the main RDS task maintains a queue structure which collects arriving monitor messages from the Brass Board process. Each cycle through the simulation, this queue is emptied as each message is uploaded to the PC/AT. A time penalty is paid for this process resulting in a reduced overall hertz rate. A better idea would be to send a monitor message specifying number of area loads per unit period of time (i.e. 6 area loads/second). Data from this message would be used to render a gauge-type instrument on the PC/AT screen (bar chart).

Areas of Improvement

The system seems to perform as expected, however, minor modifications to the overall system architecture would improve system performance. One of these modifications would be to create a separate process for the aircraft state vector interpolation software. This software currently reside within the flight model and is interrupt driven (using a timer interrupt). Incorporation of the flightline PC software into the RDS would allow greater ITARS control from the RDS PC/AT. The ITARS system software could be improved by eliminating duplicate consecutive area loads. Currently, the ITARS sends area loads at a rate specified in the ITARS User Request Message. At the fastest rate (1 hz) several consecutive area loads will have identical data in them because the aircraft has not crossed a 16 by 16 block boundary. This can also occur if the aircraft is in a tight turn. This data unnecessarily crowds the bandwidth of the ethernet and requires some additional processing time on the receiving microVAX. Currently, the Brass Board process detects duplicate consecutive area loads and discards them.

Conclusion

The ITARS Robust Demonstration System has proven to be more than a testbed for the ITARS. With its innovative user algorithms, elegant software partitioning, and clever communication software, the system provides a near real-time avionics environment for virtually any digital map storage system. In addition, the RDS can easily interface with other avionic subsystems, providing an incremental integration path from the lab environment to the aircraft environment. A high degree of independence exists between each of the user subsystems and brassboard interface, thus minimizing the difficulty of porting the software to various hardware configurations. Incorporating the user subsystems within the ITARS hardware would provide a truly self-contained, airborne TF/TA/ThA digital map navigation system.

Acknowledgments

The author wishes to thank the many people involved in the development and integration of the RDS software. To Richard McKenzie, who developed the flight model and also responsible for the overall structure of the system. To Dan Adams who wrote and improved the Route Planner and many thanks to Mark Newburn, whose thoroughness and assistance made the project a success. Thanks to Chuck Lau and Barry LeBoeuf for their administrative support. Thanks to Mark Walden and Ron Young at Hughes Aircraft, for their help and patience during system integration. To Mr. Don Small, program manager of the ITARS Program and Lt. Gordon Hengst of AFWAL/AAAS-3 who provided excellent guidance for the project.

Fractal Image Compression Using Iterated Transforms: Applications to DTED

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ABSTRACT: A review of iterated transformation image compression is presented. Generalization of simple iterated function system fractal generating algorithms to an automated iterated transformation algorithm used to compress greyscale images is reviewed. Compressed images from the Digital Terrain Elevation Database are presented, and compared with encodings using adaptive discrete cosine transformations, and mean residual vector quantization image compression techniques.

1. INTRODUCTION

Because of the increasing use of digital imagery, there is currently considerable interest in the image compression problem. In particular, image compression is a current and growing necessity for Navy applications including storage and transmittal of maps, intelligence photographs, weather information, etc. General interest in image compression has led to the establishment by the Joint Photographic Experts Group of a standard based on discrete cosine transforms (ADCT). There is also an on going effort in the research community to design improved vector quantization (VQ) methods, and to develop methods which utilize wavelet transformations. A relatively new approach to the image compression problem, iterated transformations, has been presented by Jacquin [1,2]. This method has its foundation in the theory of iterated function systems (IFSs), developed by Hutchinson [3] and Barnsley [4], and recurrent iterated function systems [5]. The iterated transform algorithm has received particular interest because of the *fractal* nature of the encoded images, and because there has been much speculation, but little information available on the capabilities of the method. The first sections of this paper review the basic methodology of the iterated transform image compression technique. This is followed by a section on the compression of the Digital Terrain Elevation Database (DTED) in which results obtained using iterated transformations are compared to ADCT and VQ methods.

2. BACKGROUND: SIMPLE EXAMPLES

This example serves as a simple illustration of some concepts involved in the iterated transform image-encoding scheme. This example is based on iterated function systems. The main concept is that the image of a set (a Sierpinski gasket, in this case) can be reconstructed from a set of transformations which may take less memory to store than the original image.

Consider the three transformations shown in figure 1. They are

$$w_1 \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & 0 \\ 0 & \frac{1}{2} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix},$$

$$w_2 \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & 0 \\ 0 & \frac{1}{2} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{2} \end{bmatrix},$$

and

$$w_3 \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & 0 \\ 0 & \frac{1}{2} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \frac{1}{2} \\ 0 \end{bmatrix}.$$

For any set S, let

$$W(S) = \bigcup_{i=1}^{3} w_i(S).$$

Denote the n-fold composition of W with itself as $W^{\circ n}$. Define $A_n = W(A_{n-1}) = W^{\circ n}(A_0)$ and arbitrarily choose A_0 as the unit square with lower left corner at the origin (i.e., $A_0 = \{(x,y) | 0 \leq x \leq 1, 0 \leq y \leq 1\}$). Then as $n \to \infty$, the set A_n converges to a limit set A_∞. In fact, for any compact set $S \subset R^2$, $W^{\circ n}(S) \to A_\infty$ as $n \to \infty$. Figure 2 shows $A_0, A_1, A_2, A_3, A_4, A_5$ and A_∞.

That all compact initial sets converge under iteration to A_∞ is important—it means that the set A_∞ is defined by the w_i only.

Each w_i is determined by 6 real values, so that for this example 18 floating point numbers are required. In single precision, this requires 72 bytes. The memory required to store an image of the set depends on the resolution; the

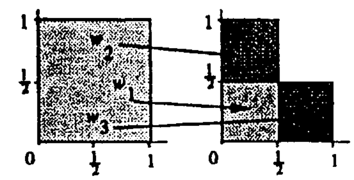

Figure 1. Three affine transformations in the plane.

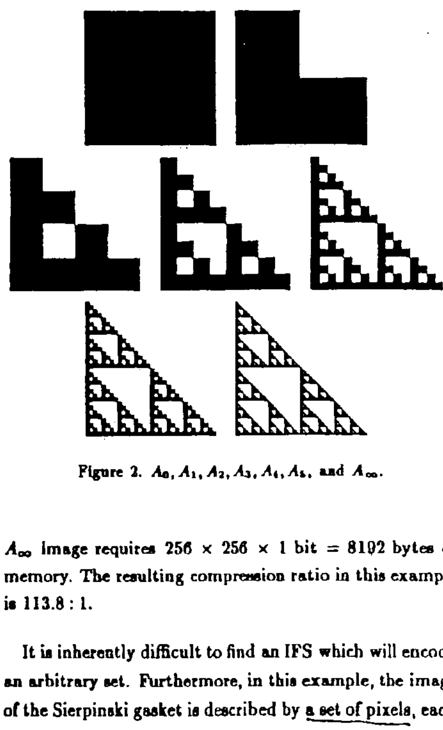

Figure 2. $A_0, A_1, A_2, A_3, A_4, A_5$, and A_∞.

A_∞ image requires 256 × 256 × 1 bit = 8192 bytes of memory. The resulting compression ratio in this example is 113.8 : 1.

It is inherently difficult to find an IFS which will encode an arbitrary set. Furthermore, in this example, the image of the Sierpinski gasket is described by a set of pixels, each being either black or white. The problem of more interest for image compression applications is the encoding of gray scale images (i.e., an image in which each pixel has many possible gray levels, not just black or white). There are two generalisations to the simple example given above which make encoding gray scale images feasible. First, instead of each w_i operating on the entire image, the w_i are restricted to operate on a section of the image. The theory of IFS's has been extended by Barnsley and Jacquin [5] to allow transforms to operate on only parts of the set rather than the entire set, in a method they call recurrent iterated function systems. The particular section, or domain, which each w_i acts on must be stored as part of the encoded image. Second, the transformations have to be generalized to three dimensions. A gray scale image can be thought of as a three-dimensional image, each pixel having an x, y coordinate, and an intensity value z. A form for the transformations which is convenient for encoding gray scale images is,

$$w_i \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_i & b_i & 0 \\ c_i & d_i & 0 \\ 0 & 0 & s_i \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \\ o_i \end{bmatrix}. \quad (1)$$

Consider the sixteen transformations,

a	b	c	d	s	e	f	o
0.5	0.0	0.0	0.5	2.0	0.75	0.0	0.0
0.5	0.0	0.0	0.5	2.0	0.75	0.25	0.0
0.5	0.0	0.0	0.5	2.0	0.50	0.0	0.0
0.5	0.0	0.0	0.5	2.0	0.50	0.25	0.0
0.5	0.0	0.0	0.5	2.0	0.0	0.5	0.0
0.5	0.0	0.0	0.5	2.0	0.0	0.75	0.0
0.5	0.0	0.0	0.5	2.0	0.25	0.5	0.0
0.5	0.0	0.0	0.5	2.0	0.25	0.75	0.0
0.0	-0.5	0.5	0.0	0.25	0.25	-0.25	0.0
0.0	-0.5	0.5	0.0	0.25	0.25	0.0	0.25
0.0	-0.5	0.5	0.0	0.25	0.5	-0.25	0.25
0.0	-0.5	0.5	0.0	0.25	0.5	0.0	0.0
0.0	-0.5	0.5	0.0	0.25	0.75	0.25	0.0
0.0	-0.5	0.5	0.0	0.25	0.75	0.5	0.25
0.0	-0.5	0.5	0.0	0.25	1.0	0.25	0.25
0.0	-0.5	0.5	0.0	0.25	1.0	0.5	0.0

where the first eight transformations are restricted to act on the region $\{(x,y)|0 \leq x \leq 1/2, 0 \leq y \leq 1/2\}$, and the second eight transformations are restricted to act on the region $\{(x,y)|1/2 \leq x \leq 1, 0 \leq y \leq 1/2\}$. Similar to the example given above, the map W is defined as the union of the w_i's. Let values of $z = 0$ be represented as black, $z = 1$ as white, with intermediate values as shades of gray. The initial image A_o is arbitrarily chosen as $z = 0.5$ for $\{(x,y)|0 \leq x \leq 1, 0 \leq y \leq 1\}$. The first six iterates, and the fixed point are shown in figure 3. In practice, the values of x, y, and z are discretized. When the image in this example is discretized as 128 × 128 pixels, and 8-bits per pixel, the encoder used in this paper [6,7] automatically encodes this image (using an equivalent set of 16 transformations) with the resulting compression equal to 356:1.

3. ENCODING AND DECODING AN IMAGE

The question that must be answered is, given an image, what is the method for finding transformations that

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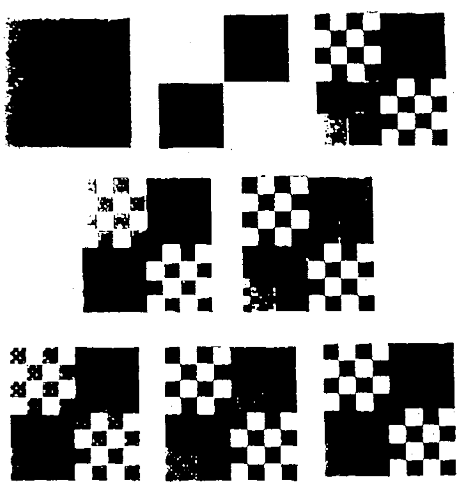

Figure 3. $A_0, A_1, A_2, A_3, A_4, A_5, A_6$, and A_∞ for the 16 transformations listed in the text.

encode it? The contractive mapping fixed point theorem suggest how to answer this question. The contractive mapping fixed point theorem guarantees that, if F is a complete metric space, and the map $W : F \to F$ is a *contractive transformation*, there exists a unique fixed point $|W| = A_\infty = \lim_{n\to\infty} W^{\circ n}(A_0)$, for any $A_0 \in F$.

Since the limit set is a fixed point,

$$|W| = W(|W|) = w_1(|W|) \cup \cdots \cup w_n(|W|). \quad (2)$$

This formula suggests how one would seek the transformations $w_1, \ldots, w_n$ which encode a given image. The goal is to have the fixed point $|W|$ approximate the desired image f. The transformations should therefore be chosen to satisfy equation 2 with $|W|$ replaced by f, i.e., the transformations, when applied to f, should result in f. The $w_1(f), \ldots, w_n(f)$ are said to *cover* the image f. Referring back to the two examples in the previous section, it is seen that, given the Sierpenski triangle, or the fractal square pattern, by satisfying equation 2 the transformations encoding these images could be found.

In the two examples, the covering $W(f)$ is exact. Given an arbitrary set f, it is not possible in general to exactly cover f with a finite number of transformations of itself. The obvious question is then: what happens if the covering $W(f)$ is approximate? A corollary of the contractive mapping fixed point theorem, which Barnsley calls the Collage Theorem, puts a bound on the error between $|W|$ and f when $W(f)$ does not exactly equal f. The theorem says that the closer the covering $W(f)$ is to the original set f, the closer the fixed point $|W|$ will be to f, and that this is especially true if the transformations composing W are very contractive.

In figure 4 part of the encoding process for this image is illustrated. The figure demonstrates how one section of the image, called a range (R_i), is covered as closely as possible by applying a transformation w_i to a domain (D_i). To complete the encoding process, a w_i and D_i must be found to cover each R_i, and the R_i's must completely tile the image. To facilitate compact specification of the transformations, the sets from which D's and R's are chosen are restricted to be geometrically simple, and limited in number. The w_i's must be chosen such that upon iteration, a fixed point is reached. In light of the collage theorem, it is surprising that when the map W is constructed, it is not necessary to impose any contractivity conditions on the individual transforms. The necessary contractivity requirement is that W be *eventually contractive* [8]. A map $W : F \to F$ is eventually contractive if there exists a positive integer m such that the m^{th} iterate of W is contractive. Note that in the gray scale example of section 2, half of the transformations are not contractive in the x direction.

As shown for the simple examples in the previous section (figures 2 and 3), decoding an image is performed by starting with an arbitrary initial image, and iterating the transformations until the fixed point is reached. This process is shown for an encoding of "tank farm" in figure 5. The compression of this image was 8.66:1, and the PSNR $= -20\log\left(\frac{\text{rms error}}{255}\right) = 33.6$ dB.

4. APPLICATION TO DTED

Application of image compression to geographic map data is of particular interest to the Navy. Geographic map data comes in a variety of formats, and there has been extensive work done in compressing map databases for various applications. In this section, the problem of compres-

Figure 4. Part of the encoding process.

sion of the Digital Terrain Elevation Database (DTED) is addressed. The database consists of elevation data for a grid of longitude–latitude coordinates where the grid points are roughly 100 meters apart. A complete description of DTED can be obtained from the Defence Mapping Agency. Alward and Nicholls [9] examined hierarchical data structures as applied to DTED. The data structures result in some data compression, although compression was not the primary goal of that investigation. In this section, the problem of interest is evaluating the performance of the iterated transform (IT) method on DTED. This would be useful for applications where data compression is the primary concern, and issues such as hierarchical structure, access time, and decoding time are of secondary importance. As a means of evaluation, the DTED images

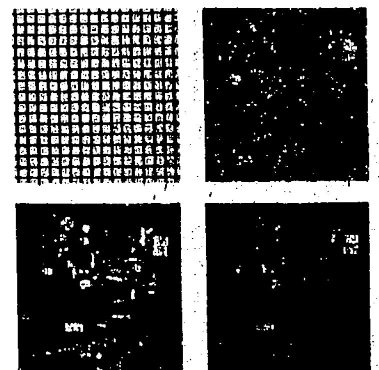

Figure 5. Initial image, first iterate, second iterate, and tenth iterate for an encoding of the "tank farm" image.

were also compressed with an ADCT and mean residual vector quantization algorithm (MRVQ). DTED data can be thought of in terms of a gray scale image where the longitude and latitude identify the pixel, and the elevation is the pixel value. For the purpose of possible Navy application, the data were transformed from their original linear scale between 0 and 10000 meters, to a logarithmic scale between 0 and 255. The quantization results in a compression from 14 bits per datapoint to 8 bits per datapoint. This logarithmic scale, shown in figure 6, represents lower elevations more accurately than higher elevations, the rationale for this being that lower elevations areas are more likely to be important for Navy applications, and that nearly all of the earth's surface (particularly near coastlines) is at relatively low elevation.

The iterated transform algorithm was identical to that used in reference 6 except for one significant modification. The algorithm was modified to encode sections of the image on coastlines with increased accuracy. For image sections that contained coastline, the error criteria was tightened. This resulted in more segmentation, and therefore higher fidelity in these areas. The ADCT algorithm used was similar to that described by Chen and Pratt [10], except for a modification similar to that described above for the iterated transform algorithm. To encode coastlines more accurately, the decision level quantizer table was compressed for sections of the image on coastlines. Improving the fidelity at the coastlines resulted in a

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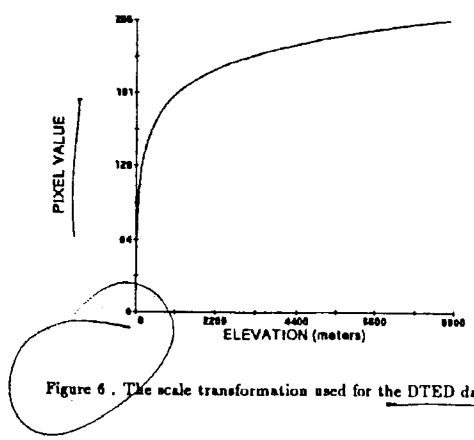

Figure 6 . The scale transformation used for the DTED data.

Figure 7 . Pixels of value 100 ±2 meters.

decrease in the overall compression-fidelity performance. The MRVQ algorithm used was based on the method described by Linde et al. [11]. Codebooks were generated from 2 sections of DTED similar to (but not including) the section tested.

The compression methods being considered are properly applied to images with a dynamic range appropriate to the number of bits used to store the image, and a relatively smooth distribution of gray level intensity values over this range. In figure 7, the 512 × 512 section of DTED, which is 1° east of that section shown in figure 8 is displayed where sea level is displayed in gray, all pixels with an elevation that is a multiple of 100 (± 2) are displayed in black, and all other elevations being displayed in white. It appears that the majority of the data contained in this section of DTED were created from 100-meter contour maps, the result being that a disproportionate number of datapoints are at multiples of 100 meters. In the southeast corner of the map, it can be seen that the number of points at 100 meters are far more dispersed. In this section of the map, roughly the number of datapoints that would be expected based on random elevations are present. The biased quantization illustrated by figure 7 is evident in other sections of DTED.

Because of this biased quantization, the reconstructed image resulting from compressed encodings will have a smoother distribution of pixel values than the original image. This will lead to an artificially poorer measured fidelity of the encoded images. In areas of DTED where the data are "properly" digitized, this situation will not occur. Because not all the data are quantized at a course resolution, but only most of it, taking advantage of this quantization is not simple. Although it has not been done here, before applying lossy compression techniques such as iterated transforms, ADCT, or VQ, requantization of the data in such a way that the majority of the datapoints retain their correct values could result in overall improved performance.

Table 1 . Results for encodings of figure 8.

Method	Compression	PSNR(dB)	Figure
IT	44.86:1	32.98	
IT	21.49:1	35.08	9
ADCT	47.33:1	30.51	
ADCT	21.08:1	34.92	10
MRVQ	32.00:1	31.36	11

Table 2 . Results for encodings of figure 12.

Method	Compression	PSNR(dB)	Figure
IT	104.11:1	34.09	
IT	42.08:1	39.03	13
ADCT	75.53:1	33.86	
ADCT	43.76:1	38.14	14
MRVQ	32.00:1	36.93	15

Tests in this section were performed on two 512 × 512

Figure 8 . Original 5° to 5° 25.6' E, 61° to 61° 12.8' N.

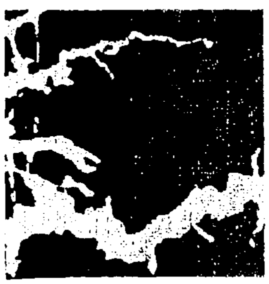

Figure 9 . The decoded IT image of figure 8.

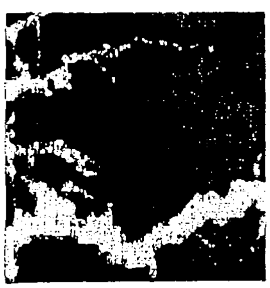

Figure 10 . The decoded ADCT image of figure 8.

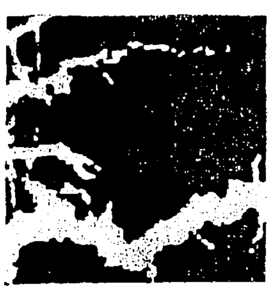

Figure 11 . The decoded MRVQ image of figure 8.

Figure 12 . Original 6° to 6° 25.6' E, 61° 12.8' to 61° 25.6' N.

Figure 13 . The decoded IT image of figure 12.

Figure 14 . The decoded ADCT image of figure 12.

Figure 15 . The decoded MRVQ image of figure 12.

sections located in the fiords of Norway. These test images are shown in figures 8 and 12. Figure 8 covers the section of the earth from 5° to 5° 25.6' east and 61° to 61° 12.8' north and figure 12 the section from 6° to 6° 25.6' east and 61° 12.8' to 61° 25.6' north. These sections of DTED were chosen because the topology of the fiords served as a severe test of the fidelity of the compression methods. A more thorough study where a broad area of the database containing a representative amount of flat and mountainous regions would be necessary in determining the compression and fidelity possible for the complete database.

Figures 9, 10, and 11 show gray scale reconstructed images from typical encodings of the image in figure 8 using iterated transforms, ADCT, and MRVQ respectively. Similarly, figures 13, 14, and 15 show reconstructed images from encodings of the image in figure 12. The fidelity and compression of these (and other) encodings are summarized in tables 1 and 2.

5. CONCLUSIONS

The compression versus fidelity results indicate that the iterated transform algorithm performed well when compared with the ADCT and MRVQ methods. Other important factors to consider when comparing these compression algorithms are access time, decoding time, and encoding time. Iterated transforms, along with ADCT are variable bit-rate methods, which would result in slower access times than the fixed bit rate MRVQ algorithm. Iterated transform encoding requires an extensive search procedure, making it slower than MRVQ, which also requires a search, albeit a shorter one. Iterated transform encoding is also slower than ADCT, which requires only a transformation and quantization. For most applications, encoding would be a one-time procedure; therefore, encoding time would not necessarily be an important concern. If an application required all or a large fraction of DTED be encoded, then the computer costs for encoding become significant. For many applications, the speed of decoding an image might be a critical requirement. The decoding for iterated transforms is a simple iteration, making it faster than ADCT (where decoding takes as long as encoding), and slower than MRVQ, which is essentially a table lookup.

6. REFERENCES

[1] A.E. Jacquin, "*A Fractal Theory of Iterated Markov Operators, with Applications to Digitial Image Coding,*" Ph.D. Thesis, Department of Mathematics, Georgia Institute of Technology, (1989).

[2] A.E. Jacquin, "Fractal Image Coding Based on a Theory of Iterated Contractive Image Transformations," *SPIE Visual Comm. and Image Processing '90*, Vol. 1360, pp. 227-239, (1990).

[3] J.E. Hutchinson, "Fractals and Self-Similarity," *Indiana University Mathematics Journal*, vol. 35, p. 5, (1981).

[4] M.F. Barnsley, *Fractals Everywhere*, Academic Press, Inc., San Diego, CA, (1988).

[5] M.F. Barnsley and A.E. Jacquin, "Application of Recurrent Iterated Function Systems to Images," *SPIE vol. 1001, Visual Comm. and Image Processing*, p. 122, (1988).

[6] E.W. Jacobs, Y.Fisher, and R.D. Boss, "Image Compression: A Study of the Iterated Transform Method" *to be published in Signal Processing*, vol. 29 no. 3.

[7] R.D. Boss and E.W. Jacobs, "Studies of Iterated Transform Image Compression, and its Application to Color and DTED," NOSC TR 1468, December 1991.

[8] Y. Fisher, E.W. Jacobs, and R.D. Boss, "Fractal Image Compression Using Iterated Transforms," submitted for publication in *Data Compression*, J.A. Storer (ed.), Kluwer Academic Publishers, Norwell, MA, (1991).

[9] Alward, H.L. and D.A. Nicholls, "Hierarchical Data Structures for a Digital Terrain Map System," AFWAL-TR-86-1177, (1986), available from DTIC.

[10] W. Chen and W.K. Pratt, "Scene Adaptive Coder," *IEEE Transactions on Communications*, vol. 32, pp. 225-232, (1984).

[11] Y. Linde, A. Buzo, and R.M. Gray, "An Algorithm for Vector Quantizer Design," *IEEE Trans. on Comm.*, vol. COM-28, no. 1, pp. 84-95, (1980).

08/513,298

AB

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/513,298	08/09/95	MARGOLIN	J 02055.P002

B3M1/0315

EDWIN H TAYLOR
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EXAMINER	
NGUYEN, T	
ART UNIT	PAPER NUMBER
	16

DATE MAILED: 03/15/96

EXAMINER INTERVIEW SUMMARY RECORD

All participants (applicant, applicant's representative, PTO personnel):

(1) DAN DEVAS (3) ______

(2) TAN NGUYEN (4) ______

Date of interview 03/08/96 and 03/14/96

Type: ☒ Telephonic ☐ Personal (copy is given to ☐ applicant ☐ applicant's representative).

Exhibit shown or demonstration conducted: ☐ Yes ☒ No. If yes, brief description: ______

Agreement ☒ was reached with respect to some or all of the claims in question. ☐ was not reached.

Claims discussed: ______

Identification of prior art discussed: BUNESKY, ULRICH, RAYMER ET AL, JACOBS ET AL, PATRICK.

Description of the general nature of what was agreed to if an agreement was reached, or any other comments: the applicant's representative argued that none of the references disclose the terrain data, representing real terrain terrestrial terrain as at least one polygon, is generated from elevation data. Examiner agreed to reconsider the application in light of the argument. However, an written amendment is requested in order for examiner to response.

(A fuller description, if necessary, and a copy of the amendments, if available, which the examiner agreed would render the claims allowable must be attached. Also, where no copy of the amendments which would render the claims allowable is available, a summary thereof must be attached.)

Unless the paragraphs below have been checked to indicate to the contrary, A FORMAL WRITTEN RESPONSE TO THE LAST OFFICE ACTION IS NOT WAIVED AND MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW (e.g., items 1–7 on the reverse side of this form). If a response to the last Office action has already been filed, then applicant is given one month from this interview date to provide a statement of the substance of the interview.

☒ It is not necessary for applicant to provide a separate record of the substance of the interview.

☐ Since the examiner's interview summary above (including any attachments) reflects a complete response to each of the objections, rejections and requirements that may be present in the last Office action, and since the claims are now allowable, this completed form is considered to fulfill the response requirements of the last Office action.

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Tan Nguyen
Examiner's Signature

PTOL-413 (REV. 1-84)

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02055.P002C

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

OFFICIAL

In re Application of: Jed Margolin	Examiner: Nguyen, T.
Application No.: 08/513,298	Art Unit: 2304
Filed: August 9, 1995	
For: Pilot Aid Using Synthetic Reality	
This is a Continuation of: Serial No: 08/274,394 Filed: July 11, 1994	

Hon. Commissioner of Patents and Trademarks
Washington, D.C. 20231

AMENDMENT AND REMARK

Sir:

This amendment and remark is responsive to the Examiner Interview Summary mailed on March 15, 1996 and the telephonic interview with the Examiner on April 18, 1996. During the interview on April 18, 1996, the Examiner indicated that the application would be allowed if a response was filed with the remark contained below. Although the Examiner and Applicant did not discuss the following amendments, Applicant believes these amendments have no affect on the allowability of this case. If the Examiner determines that these amendments affect the allowability of this case, Applicant requests the Examiner contact the Applicant. Applicant would like to thank the Examiner for the thorough search performed in this case, as well as the Examiner's effort in understanding the invention claimed. Applicant looks forward to receiving the notice of allowance in the next couple of weeks.

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office in accordance with 37 CFR § 1.6(d), on the date shown below.

Name: Connie West

Signature: Connie West

Date: April 19, 1996

AMENDMENT

In the Claims:

Please replace "23" in line 1 of claim 31 with --38--.

Please replace "23" in line 1 of claim 32 with --38--.

Please delete "by" from the last line of claim 39.

REMARK

Claims 1-28 and 31-39 remain in the application. No claims have been canceled. Claims 31 and 32 have been amended.

Prior to this amendment, claims 31 and 32 were mistakenly left dependent upon the wrong claim. By this amendment, claims 31 and 32 are now dependent on allowable claim 38. For the Examiner's convenience, Applicant points out that claims 33 and 35 are dependent on claim 31, while claim 34 is dependent on claim 32. If the Examiner determines that these amendments affect the allowability of this case, Applicant requests the Examiner contact the Applicant, who will promptly fix or cancel these claims.

35 U.S.C. §103 rejection, over Beckwith in view of Behensky

The Examiner has rejected Claims 1-12, 14-28, and 31-39 under 35 U.S.C. §103 as being obvious over Beckwith, et al. ("Beckwith") in view of Behensky, et al. ("Behensky") or a brochure from Atari Game Corp. (Hard Driving) or a brochure from Atari Game Corp. (Steel Talons) and further in view of Ulrich, or Jacobs et al., or Raymer et al. or Patrick. As to Beckwith, Behensky, and the two Atari brochures, the Applicant incorporates herein by reference the arguments made in the Response After Final submitted in the parent application on July 10, 1995, and entered in this application by the Preliminary Amendment filed on October 18, 1995. As stated in the Response filed on July 10, 1995, the Beckwith, Behensky, and two Atari Game Corp. brochures, taken individually or in combination, do not teach or make obvious a polygon database

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representing real terrestrial terrain where that polygon database was generated from elevation data of real terrestrial terrain (see Claim 1, 7, and 36). As agreed upon by the Examiner and Applicant, Ulrich, Jacobs et al., Raymer et al., and Patrick, taken individually or in combination, also do not teach or make obvious the polygon database contained in claims 1, 7, and 36. Since none of the references cited in this rejection, individually or in combination, teach or make obvious the invention as claimed, Applicant respectfully requests the Examiner allow claims 1, 7, and 36 as agreed upon by the Examiner and Applicant. Although Applicant argues around references cited in this rejection, Applicant does not concede that there is a suggestion to combine these references.

Claims 2-6, 8-12, 14-15, 17-18, 20-21, 23-24, 26-28, 31-35, and 37-39 of Applicant's present invention are each dependent on one of allowable base claims 1, 7, and 36. For at least these reasons, it is respectfully submitted that the rejected claims are allowable over the cited prior art.

35 U.S.C. §103 rejection, over Beckwith in view of Behensky, and further in view of the sales brochure from the Polhemus Company

The Examiner has rejected Claim 13 under 35 U.S.C. §103 as being obvious over Beckwith and Behensky in view of the sales brochure from the Polhemus Company. As previously stated, the Beckwith and Behensky references, taken individually or in combination, do not teach or make obvious a polygon database representing real terrestrial terrain where that polygon database is generated from elevation data of real terrestrial terrain (see Claim 13). As stated in the Office Action mailed January 22, 1996, the sales brochure from the Polhemus Company "suggests the commercial available [sic] of a position and orientation sensor which can be used on a head mounted display". The brochure from Polhemus Company clearly does not teach or make obvious the above-described polygon database. Since none of the references cited in this rejection, individually or in combination, teach or make obvious the invention as claimed, Applicant respectfully

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request the Examiner allow claim 13 as agreed upon by the Examiner and Applicant. Although Applicant argues around references cited in this rejection, Applicant does not concede that there is a suggestion to combine these references.

Claims 16, 19, 22, and 25 are each dependent on independent claim 13. For at least these reasons, it is respectfully submitted that these rejected claims are allowable over the cited prior art.

Conclusion

As agreed upon by the Examiner and the Applicant, the rejections have been overcome and the claims are now in condition for allowance. Accordingly, Applicant respectfully requests reconsideration of this application, withdrawal of the objection, and allowance of the claims.

Invitation for a telephone interview

The Examiner is invited to call the undersigned at 408-720-8598 if there remains any issue with allowance of this case.

Charge our Deposit Account

Please charge any shortage to our Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Date: 4/18, 1996

Daniel M. De Vos
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(408) 720-9397 Facsimile

Facsimile Transmittal Sheet

Date: 04/19/96

OFFICIAL

URGENT

Deliver to: Tan Nguyen

Fax No. (703) 308-5358

FROM BSTZ:

From: Daniel De Vos
Operator: Connie West
Page 1 **of** 5

To Firm: U.S. PATENT AND TRADEMARK OFFICE
Phone:
Your Ref: Applic. No.: 08/513,298
Our Ref: 002055.P002C
Title: Pilot Aid Using Synthetic Reality

Message:

Enclosed please find an Amendment and Remark responsive to the Examiner Interview Summary mailed on 3-15-96 and the telephonic Interview with the Examiner on 4-18-96.

18/513,298

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
		MARCH	

B3M1/0418

EDWIN H TAYLOR
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12400 WILSHIRE BLVD SEVENTH FLOOR
LOS ANGELES CA 90025

NGUYEN, T

EXAMINER

ART UNIT	PAPER NUMBER
	18

DATE MAILED:

NOTICE OF ALLOWABILITY

PART I.

1. [X] This communication is responsive to the amendment filed on 07/19/96
2. [X] All the claims being allowable, PROSECUTION ON THE MERITS IS (OR ~~REMAINS~~) CLOSED in this application. If not included herewith (or previously mailed), a Notice Of Allowance And Issue Fee Due or other appropriate communication will be sent in due course.
3. [X] The allowed claims are 1-28, 31-39 (now renumbered as 1-37)
4. [X] The drawings filed on 02/13/95 are acceptable.
5. [ ] Acknowledgment is made of the claim for priority under 35 U.S.C. 119. The certified copy has [ ] been received. [ ] not been received. [ ] been filed in parent application Serial No. ______, filed on ______.
6. [ ] Note the attached Examiner's Amendment
7. [ ] Note the attached Examiner Interview Summary Record, PTOL-413.
8. [X] Note the attached Examiner's Statement of Reasons for Allowance
9. [ ] Note the attached NOTICE OF REFERENCES CITED, PTO-892.
10. [ ] Note the attached INFORMATION DISCLOSURE CITATION, PTO-1449

PART II.

A SHORTENED STATUTORY PERIOD FOR RESPONSE to comply with the requirements noted below is set to EXPIRE THREE MONTHS FROM THE "DATE MAILED" indicated on this form. Failure to timely comply will result in the ABANDONMENT of this application. Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

1. [ ] Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL APPLICATION, PTO-152, which discloses that the oath or declaration is deficient. A SUBSTITUTE OATH OR DECLARATION IS REQUIRED.
2. [ ] APPLICANT MUST MAKE THE DRAWING CHANGES INDICATED BELOW IN THE MANNER SET FORTH ON THE REVERSE SIDE OF THIS PAPER.
   a. [ ] Drawing informalities are indicated on the NOTICE RE PATENT DRAWINGS, PTO-948, attached hereto or to Paper No. ______ CORRECTION IS REQUIRED.
   b. [ ] The proposed drawing correction filed on ______ has been approved by the examiner. CORRECTION IS REQUIRED.
   c. [ ] Approved drawing corrections are described by the examiner in the attached EXAMINER'S AMENDMENT. CORRECTION IS REQUIRED.
   d. [ ] Formal drawings are now REQUIRED.

Any response to this letter should include in the upper right hand corner, the following information from the NOTICE OF ALLOWANCE AND ISSUE FEE DUE: ISSUE BATCH NUMBER, DATE OF THE NOTICE OF ALLOWANCE, AND SERIAL NUMBER.

Attachments:

- Examiner's Amendment
- Examiner Interview Summary Record, PTOL-413
- X Reasons for Allowance
- Notice of References Cited, PTO-892
- Information Disclosure Citation, PTO-1449
- Notice of Informal Application, PTO-152
- Notice re Patent Drawings, PTO-948
- Listing of Bonded Draftsmen
- Other

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I. **EXAMINER'S STATEMENT OF REASONS FOR ALLOWANCE**

II. This communication is an Examiner's reasons for allowance in response to application filed on August 09, 1995, assigned serial 08/513,298 and titled "PILOT AIDED USING SYNTHETIC REALITY".

III. The following is an Examiner's statement of reasons for the indication of allowable subject matter:

1. After carefully reviewing the application in light of the prior art of record, the amended claims and additional search of all the possible areas relevant to the present application a set of related prior art have been found, but those prior art references are not deemed strong to make the application unpatentable. Thus, it is found that the application is now in condition for allowance.

2. Although the prior art disclose several claimed limitations, none of the references teach a pilot aid which uses an aircraft's position and attitude to transform data from a digital data base to present a pilot with a synthesized three dimensional projected view of the world which includes a digital data base comprising terrain data representing real terrestrial terrain as at least one polygon and said terrain data generated from elevation data of the real terrestrial terrain (claims 1, 7, 13 and 36).

3. The closest references have been found were Beckwith et al., Behensky et al., Ulrich , Jacobs et al., Raymer et al., Patrick. However, taken individually or in combination, they do not teach or make obvious a polygon database representing real terrestrial terrain where that polygon database was generated from elevation data of real terrestrial terrain.

4. Claims 1-28 and 31-39 are allowable over the prior art of record (now renumbered as 1-37).

IV. Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Tan Nguyen, whose telephone number is (703) 305-9755. The examiner can normally be reached on Monday-Thursday from 7:30 AM-6:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin J. Teska, can be reached on (703) 305-9704. The fax phone number for this Group is (703) 305-9564.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-3800.

TAN NGUYEN
June 17, 1996

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office

Address: Box ISSUE FEE
COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

NOTICE OF ALLOWANCE AND ISSUE FEE DUE

☐ Note attached communication from the Examiner

☐ This notice is issued in view of applicant's communication filed ____________

SERIES CODE/SERIAL NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT	DATE MAILED
		37		

First Named Applicant

TITLE OF INVENTION

	ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE

THE APPLICATION IDENTIFIES ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED.

THE ISSUE FEE MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED.

HOW TO RESPOND TO THIS NOTICE:

I. Review the SMALL ENTITY Status shown above. If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is changed, pay twice the amount of the FEE DUE shown above and notify the patent and Trademark Office of the change in status, or

B. If the Status is the same, pay the FEE DUE shown above.

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First Named Applicant: [illegible]

TITLE OF INVENTION: PILOT AID USING SYNTHETIC ~~[illegible]~~ ENVIRONMENT

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section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person. 17-28, 31-35 and 38-39

5. Claims 1-12, 14-28 and 31-39 are rejected under 35 U.S.C. § 103 as being unpatentable over Beckwith et al (4,660,157) in view of Behensky et al. (5,005,148) or a brochure from Atari Game Corp. (Hard Driving') or a brochure from Atari Game Corp. (Steel Talons) and further in view of Ulrich (an article entitle "Tactical Mapping in Combat Aircraft"), or Jacobs et al. (an article entitle "Fractal Image Compression Using Iterated Transforms Applications To DTED"), or Raymer et al. (Advance Terrain Data Processor), or Patrick (Itars Robust Demonstration System Integration).

5.1. With respect to claims 1, 5-7, 11-12, 14-16 and 36-37, Beckwith et al. discloses a digital system for producing a real time video display in perspective of terrain over which an aircraft is passing on the basis of compressed digital data stored on a cassette tape (see at least an abstract). Beckwith et al. discloses that the system includes a position determining means for locating the aircraft's position in three dimensions and an attitude determining means for determining the aircraft's orientation in three dimensional space (see at least figure 1 and columns 5 and 6). Beckwith et al. further discloses that the system includes a digital data base means for storing a compressed terrain data (see at least the abstract). Beckwith et al. also discloses a computer means for reading compressed terrain data from the digital data base means in a controlled manner based on the instantaneous geographical of the aircraft as provided by the aircraft navigation computer system, reconstructing the compressed data by suitable processing and writing the reconstructed data into a scene memory, and then providing a 3D perspective on the display (see at least columns 2 and 3).

Beckwith et al. does not explicitly disclose that a digital data base means containing polygon data representing terrain and manmade structures. However, Behensky et al. suggests a driving simulator for a video game which includes the road and other terrain are produced by mathematically transforming a three-dimensional polygon data base (see at least column 2, lines 33-38). The suggestion of Behensky et al. in at least column 2 would have motivated one of ordinary skill in the art to combine with the system of Beckwith et al. in order to provide a significant reduction of data base storage and a larger geographic areas can be stored so that it is not necessary to generate a data base of each mission. Similarly, the digital data base means containing polygon data representing terrain and manmade structures is also taught in a brochure from Atari Game Corp. (Hard Driving') or a brochure from Atari Game Corp. (Steel Talons).

Behensky et al., the brochures of Atari Game Corp. do not explicitly disclose that the terrain data is generated from elevation data of the real terrestrial terrain. However, the feature is well known and old (see Ulrich, Raymer et al., Jacobs et al., and Patrick, for examples). It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Ulrich, Raymer et al., Jacobs et al., and Patrick with the system of Beckwith in order to improve the system for pilot aid by providing displaying large qantitates of cartographic and mission data including terrain elevation data and cultural feature data.

Thus, because of the motivation set forth above, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to combine the teachings of Behensky et al. or the brochure from Atari Game Corp. (Hard Driving') or the brochure from Atari Game Corp. (Steel Talons) with the system of Beckwith et al., and Ulrich, Raymer et al. or Jacobs et al. or Patrick.

5.2. With respect to claims 2-3 and 8-9, Beckwith et al. discloses the claimed invention as discussed above but does not explicitly discloses that the position determining means comprises a standard system for retrieving and processing data from the global positioning system and the attitude determining means comprises a standard avionics systems. However, the use of the standard system for retrieving and processing data from global positioning system and the standard avionics systems are well known effective and efficient means for determining the position and the orientation of the aircraft. For examples, the Maher patent (4,485,383) shows a receiver for receiving global positioning system and the Timothy patent shows a method for determining the orientation of a moving object form a single GPS receiver and producing roll, pitch, and yaw information. It would have been obvious to one of ordinary skill in the art at the time of the invention to utilize the global positioning system and the standard avionics system in such a system as taught through Beckwith et al. because it would produce high degree of accuracy in determining the position and orientation of the aircraft including roll, pitch, and yaw information.

5.3. With respect to claims 4 and 10, Beckwith et al. does not specifically disclose that the digital data base means comprises a CD rom disc and CD rom drive. However, the use of CD rom disc and CD rom drive for storing data is well known effective and efficient means for storing any data. It would have been obvious to one of ordinary skill in the art at the time of the invention to utilize CD rom disc and CD rom drive in such a system as taught through Beckwith et al. because it would permit high degree of accuracy in the storing and restoring data, random access to the data so that the requirements for cache storage are reduced.

5.4. With respect to claims 17-28, 31-35 and 38-39, both Patrick et al. and Raymer et al. articles disclose the detail about elevation data.

6. Claim 13 is rejected under 35 U.S.C. § 103 as being unpatentable over Beckwith et al and Behensky et al. as applied to claims 1-12 above, and further in view of the sales brochure from the Polhemus company.

Beckwith et al. and Behensky et al. disclose the claimed invention except for a head mounted display means worn by the pilot and an attitude determining means for determining the orientation of the pilot's head in three dimensional space. However, the sales brochure from the Polhemus company suggests the commercial available of a position and orientation sensor which can be used on a head-mounted display. The suggestion of the Polhemus company would have motivated one of ordinary skill in the art to combine the teaching of Polhemus company with the system of Beckwith et al. in order to allow the pilot to have a complete range of motion to receive a synthesized view of the world, a complete unhindered by the aircraft structure. Thus, because of the motivation set forth above, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to combine the teachings in Polhemus's brochure and Beckwith et al. patent.

7. All claims are rejected.

Remarks

8. Applicant's arguments filed on July 14, 1995 have been fully considered. Upon the amended claims which contain new issue and the further update search, new ground of rejection has been set forth above.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Tan Nguyen, whose telephone number is (703) 305-9755. The examiner can normally be reached on Monday-Thursday from 7:30 AM-6:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin J. Teska, can be reached on (703) 305-9704. The fax phone number for this Group is (703) 305-9564.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-3800.

TN

TAN NGUYEN
December 16, 1995

KEVIN J. TESKA
SUPERVISORY PATENT EXAMINER
GROUP 2300

TO SEPARATE, HOLD TOP AND BOTTOM EDGES, SNAP-APART AND DISCARD CARBON

FORM PTO-892 (REV. 2-92)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

NOTICE OF REFERENCES CITED

SERIAL NO.	GROUP ART UNIT	ATTACHMENT TO PAPER NUMBER
08/513,281	2304	15

APPLICANT(S): MARGOLIN

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUB-CLASS	FILING DATE IF APPROPRIATE
	A						
	B						
	C						
	D						
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	I						
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FOREIGN PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUB-CLASS	PERTINENT SHTS. DWG.	PERTINENT PP. SPEC.
	L								
	M								
	N								
	O								
	P								
	Q								

OTHER REFERENCES (Including Author, Title, Date, Pertinent Pages, Etc.)

R	Ulrich, "Tactical Mapping in Combat Aircraft", IEEE 1988, pp. 74-78
S	Raymer et al. "Advanced Terrain Data Processor", IEEE 1994, pp. 636-639.
T	Patrick et al., "ITARS Robust Demonstration System Integration", IEEE 1988, pp. 83-87.
U	Jacobs et al., "Fractal Image Compression Using Iterated Transforms: Applications to DTED", IEEE 1994, pp. 1122-1128

EXAMINER	DATE
Tan Nguyen	12/18/95

* A copy of this reference is not being furnished with this office action. (See Manual of Patent Examining Procedure, section 707.05 (a).)

0143

TACTICAL MAPPING IN COMBAT AIRCRAFT

Ulrich Buening

ESG Elektronik-System-Gesellschaft mbH
Munich, Federal Republic of Germany

ABSTRACT

During the last decade Geographical Information Systems (GIS) have been increasingly used in computer aided planning and mapping. An application of GIS in combat aircraft is tactical mapping. Tactical mapping enables the pilot to recognize spontaneous complex-air-to ground relations such as danger zones and dead space. Tactical information (e.g. flight path, danger zones) is combined with selected geographical information (e.g. rivers, contours) and displayed on a monitor. This geographical information and some tactical data (e.g. danger zones) are derived from a GIS. The main aspect of a tactical map is to permit the pilot good visual interpretation of the displayed information.

INTRODUCTION

Improved mission effectiveness for combat aircraft requires both pilot-friendly generation of the target area scenario and an easy-to-recognize representation of the threat assessment.
Modern methods of computer aided mapping provide new ways of developing tactical representation given to the pilot. A precondition for this is a computer relevant data-base holding geographical information.
In the following the evaluation of "Tactical Maps" is described. They are to be regarded as possible "display formats" in cockpits of the future.
The graphic hardware used is Bosch's CAD Station PIC 1000. The host computer is a DEC VAX 750.

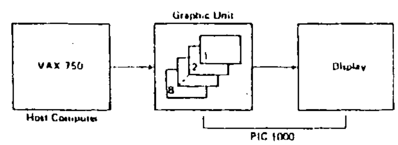

Figure 1: Hardware configuration used for developing "Tactical Maps"

GIS DEVELOPMENT

The first step is development of a GIS using the DLMS-DTED and the PACE data-base. The chosen test area is the landscape of the Black Forest (Longitude = 8-10 degree, Latitude = 48-49 degree). The raw data are provided by the "Digital Landmass System Terrain Elevation Data-Base" (DLMS-L1-DTED) of the Defense Mapping Agency (USA) and the "Project of Automated Charts Europe" (PACE) data-base of the Directorate of Military Survey (UK). The DLMS-L1-DTED data contain the heights above a specified level (NN) in a 3 x 3 seconds arc raster (3 x 6 for latidudes greater than 50 degrees). The coordinate frame is the World Geodetic System 1972 (WGS 72). The PACE data contain all the cartographic objects (features) needed for automated plotting of the "Tactical Pilotage Chart" (TPC) and the "Operational Navigation Chart" (ONC). The features are split into more than 200 categories. The coordinates are $\bar{x},\bar{y}$, digitized from the sheets of the "Joint Operation Graphics" (JOG).
For the GIS the coordinate frame of the European Datum 1950 (ED 50) is chosen. The coordinates are UTM. Thus the following transformations are necessary:

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- PACE

$$x(UTM)=a01+a11*\bar{x}+a21*\bar{y}+a31*\bar{x}*\bar{y}$$
$$y(UTM)=a02+a12*\bar{x}+a22*\bar{y}+a32*\bar{x}*\bar{y}$$

The coefficients are evaluated by four points known in $\bar{x},\bar{y}$ digitized and x,y UTM. They are implicitly given in the data-base for each sheet.

- DLMS-DTED

$$L,B,H(ED\ 50)=f(d_i,p_i,m,L,B,H(WGS\ 72))$$

The vector of rotation d_i, the vector of translation p_i and the scale-factor m are the parameters needed for the coordinate frame transformation WGS 72 to ED 50 for the chosen area.

$$x,y(UTM),H=f(L,B),H$$

Hence an isometric height raster in the UTM System is evaluated by linear interpolation. For this the four heights in the neighbourhood of the desired raster point are taken into account.

$$H_{nm}= f(x_i,y_i,H_i) \quad i=1,2,3,4$$

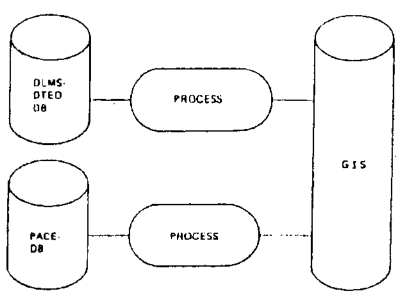

Figure 2: Development of a GIS

GEOGRAPHICAL AND TACTICAL INFORMATION

Using the GIS geographical and tactical information is derived and presented on the monitor. The scale choosen is 1 : 250,000. On the monitor this means one Pixel is equal to 127 meters. The tactical information derived from the GIS is sensor-covering:

- optical visibility (sensor = eye of the pilot)
- electrical visibility (sensor = radar, e.g. threat from a SAM-site)

Tactical information that is not derived from the GIS (e.g. home base), is stored seperately in a tactical data-base.

For the calculation of the sensor-coverings the earth's curvature is taken into account by the following approximation formula:

$$\Delta H=a^2/(2*R)$$

The derived partial geographical information comprises:

- elevation tints
- relief maps illuminated from several directions
- feature maps
- perspective views of the morphology

The elevation tints show the areas above a given height H = const. The painted shade lightens with height. The relief maps show a shading of the terrain illuminated from a given direction. The best impression is given by illuminating from the North-West.
The following features (selected from the PACE object-categories specified for the ONC and summarized) are chosen for the maps:

- waters of first order
- streets of first order
- towns with more than 10,000 inhabitants
- railways of first order

More information is not practical for the interpretation by displaying it on the graphic monitor on this scale. An assistant grid of latitude and longitude can be additionally calculated.
The pespectiv views show a central projection of the terrain with and without threat. The 3D impression of the morphology is given by the deformation of the grid-planes. The observer's orientation can be that of the pilot or any other.

Parameters necessary for the derivation of the geographical and tactical information are the 3D position and the attitude of the observer (usually the pilot).

Figure six gives a summary of the above-mentioned tools.

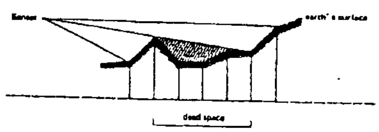

Figure 3: Sensor covering, dead space

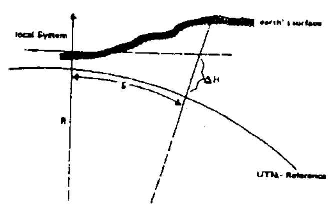

Figure 4: Earth's curvature

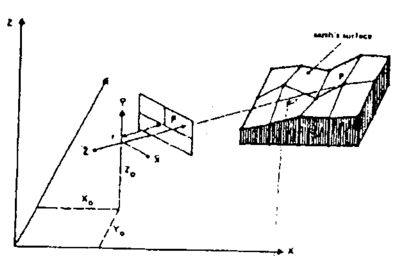

Figure 5: Central projection

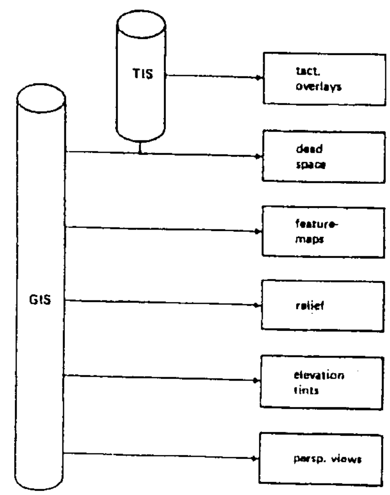

Figure 6: Tools organisation chart

EXAMPLES OF "DISPLAY FORMATS"

The derived geographical and tactical information have to be combined in a manner such that the pilot is given the best assessment in his operations. With the exception of the perspective views all the information is stored as pixel data in several layers of the frame buffer and can be selected by pushing a button. The sensor coverings and the elevation tints are transparent. The figures 7 to 11 show examples of displayed geographical information combined with tactical information for applications in combat aircraft recommended by ESG.

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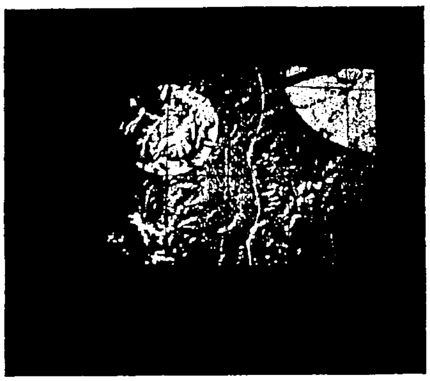

Figure 7: Relief map with elevation tints (670 m and 1000 m), waters and geographic grid.
SAM covering for flight height 100 m above terrain, flight path.

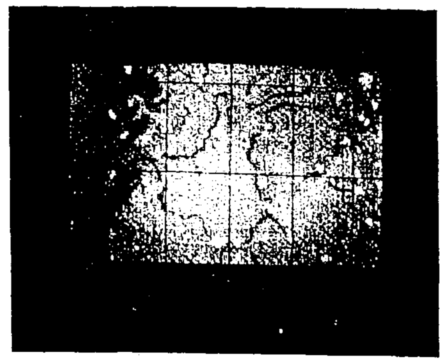

Figure 9: Map with elevation tint (670m), waters, streets, towns, railways and geographic grid.

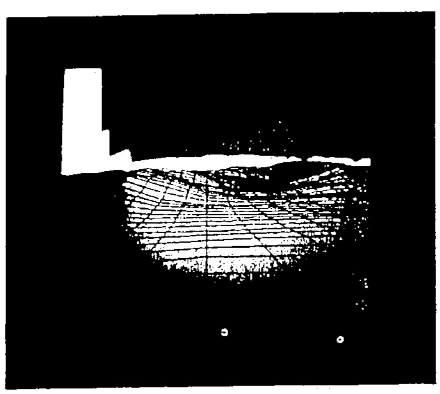

Figure 8: Perspective view of the morphology, observer located at the position L = 8°04', B = 48°20', 150 m above the terrain. Threat shown as a red cloud.

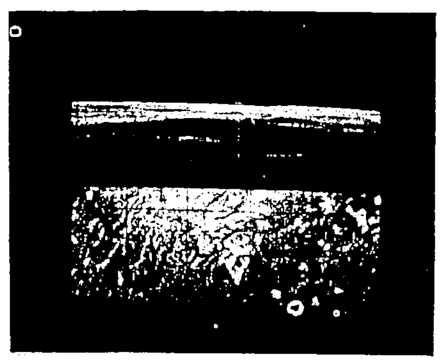

Figure 10: Bottom: geographic information like Figure 9 and relief including the area visible for the pilot flying at a height of 60 m above terrain (located at the aircraft symbol).
Top: pilot's perspective view of the morphology.

polygon

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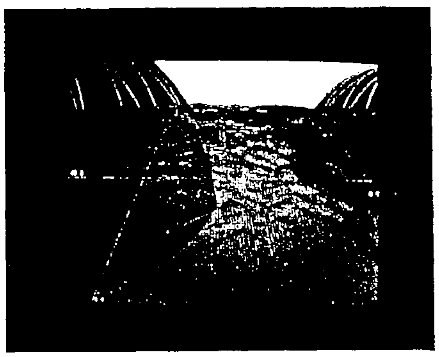

Figure 11: perspective "over"-view of the morphology from a desired area. Contour lines, rough threat environment.

CONCLUSION

The PACE data base and the DLMS-DTED are suitable for new tactical representations on displays in combat aircraft. A great advantage of the PACE data base is selectivity. For that a decluttering of the information is possible without renounce on them. If the tactical information predominates, the geographical information can be reduced successively. Thus the pilot is not inundated with information.
The selection of a scale larger than 1 : 200,000 is not to be recommended, because the cartographic generalization of the PACE data base would lead to inconsistencies.

ACKNOWLEDGEMENTS

The reported work was sponsored by the DOD (BMVg, BWB) of the FRG under contract number: E/ L31N/ G0538/ G5117. We thank for the opportunity to present the reported results.

01433

Advanced Terrain Data Processor

Authors:
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Tom Weingartner

Honeywell Defense Avionics Systems
9201 San Mateo Boulevard NE
Albuquerque, New Mexico 87113-2227

Abstract: The Quiet Knight Technology Demonstration Program has developed an integrated avionics system that greatly enhances covert penetration capabilities of the C-130 aircraft. The system centers around an enhanced digital map called the Advanced Terrain Data Processor (ATDP). The ATDP enhances covert capability by fusing data from different sensors and sources. Aggressive terrain following is accomplished by blending Low Probability of Intercept (LPI) Radar, Ladar, and radar altimeter with Digital Terrain Elevation Data (DTED). Accurate navigation, required by terrain following, combines data from the INS, GPS, radar altimeter, and DTED. Threat avoidance is accomplished by merging on-board and over the horizon intelligence data with DTED culminating in an automatic replan. All three functions combine to provide excellent situational awareness that keeps the aircraft safe from terrain impact and enemy engagement.

System Overview

The ATDP is interconnected with multiple avionics systems to manage the aircraft mission. Figure 1 shows the avionics tested during the various phases of the program. Covert penetration is possible due to an aggressive terrain following algorithm flying set clearances of 150 to 1000 feet and by minimizing emissions from the aircraft with sophisticated sensor control techniques. Utilizing threat detection methods which allow the aircraft to detect and locate unplanned threats prior to exposure, planning routes on the ground and in-flight which minimize exposure to all threats and improving the crew's situational awareness through multiple video displays also aid in the covert capabilities.

ATDP Description

Successful mission management is possible due to the ATDP that fuses data from several external

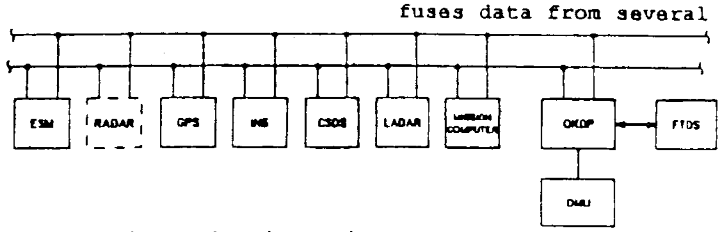

Figure 1 Quiet Knight System Diagram

0-7803-2425-0/94 $4.00 © 1994 IEEE

sources. Information is captured graphically for display to the crew and provides vehicle management commands to both the crew and other avionics systems. Figure 2 is a block diagram of the hardware which executes these management tasks.

Display Formats

Three video outputs are generated within the ATDP. Video Engine 1 provides the plan-view map in a redundant RGB format. The plan-view map displays either paper chart, DTED color banded, or still-picture information. Threat information is displayed with translucent shading indicating the detection or line of sight for threats and a single ring indicating the lethal range. Planned threats are shaded in white while unplanned threats are shaded with purple. The Intervisibility Engine calculates the display pixels which must be shaded in real-time based on the terrain following set clearance. Video Engine 2 provides two monochrome outputs: ridgelines and energy elevation profiles (EESCAN). The ridgeline display shows six lines at 1 nmi. spacing with a field of view of +/- 30 degrees. The EESCAN display gives the pilot vertical steering information with the elevation line indicating the terrain plus commanded set clearance for the planned aircraft route. The energy line displays the maximum climb the aircraft perform. Distance is displayed logarithmically along the x-axis from 0.1 nmi. to 20 nmi. The y-axis represents the flight path angle from +15 to -20 degrees. The elevation line includes any combination of stored DTED and obstacle information, terrain from the RADAR, and terrain and obstacle data from the LADAR.

Steering Commands

The ATDP provides passive pitch and roll commands to the pilot on the ADI. The roll is based on the preplanned route and

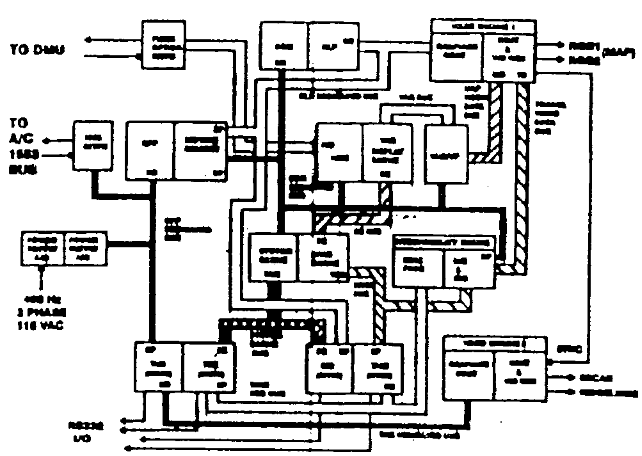

Figure 2 ATDP Block Diagram

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aircraft characteristics and attempts to minimize cross-track errors while the pitch commands are generated by an ADLAT algorithm tailored to a C-130 vehicle. The pitch commands attempt to maintain the commanded set clearance at all times.

Elevation Profile

The elevation profile input to ADLAT for vertical steering and the EESCAN display format is fused from a variety of sources. The baseline profile is based on stored DTED data provided by the Defense Mapping Agency. Blended with this data is information from forward looking sensors. RADAR and LADAR data can be blended into the DTED profile. The forward looking sensors are commanded by the ATDP to scan a limited region ahead of the aircraft. This blending mechanism provides two important enhancements to the vehicle management. First, by blending sensor data with DTED, the sensors need only scan 1.8 nmi. ahead of the aircraft and can reduce their emitting power. The scan region is further limited to the planned route which significantly reduces the detection probability. Secondly, the forward looking sensor improves flight safety concerns by correcting or verifying the DTED data.

Threat Avoidance

The ability to respond quickly and efficiently to in-flight threats is critical to maintaining covert status. The on-board Electronic Support Measures (ESM) can detect threats prior to entering line-of-sight. ESM detected threats are sent to the Constant Source Data System (CSDS) for correlation to the present threat database. CSDS also receives broadcast threat information and performs the same correlation function. The CSDS will update known threats or issue new threats to the ATDP as necessary. When the ATDP receives a new threat, it updates its database, calculates the line-of-sight for the threat that will be displayed on the planview map, and determines if evasive action is required. The ATDP is constantly searching the planned route for intersections with unplanned threats. Should an intersection be detected within 25 nmi. of present position, an in-flight mission replan can be invoked. The in-flight replan is identical to the ground based route planner and is a modified A-Star algorithm. The route generated will be the lowest cost route based on exposure to a threat's detection and lethal regions, path length, path vertical changes, and a measure of each point on the path's vulnerability.

Navigation

An highly accurate navigation solution is key to safely executing the previous functions. The ATDP includes an 18 state Kalman filter that blends INS, GPS, and terrain referenced measurements to correct for INS errors. The incorporation of both GPS and terrain referenced measurements gives this navigation filter the unique ability to correct for errors in the DTED database, further improving safety of flight.

Summary

The ATDP is a vehicle management system. It controls the scan patterns and power of the forward looking sensors. It also issues steering commands along a planned route which minimize exposure to threats and has been determined to be safe for low level terrain following. The aircraft survivability is dramatically improved since the ingress, mission task, and egress have been made safer due to the enhanced situational awareness and improved terrain following. This system increases the likelihood that both the aircraft and its crew will return from each and every mission, and that is a feature whose value is immeasurable.

ITARS ROBUST DEMONSTRATION SYSTEM INTEGRATION

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Mr. G. Mel Barney

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Plano, Texas

Abstract

With the availability of Digital Terrain Elevation Data (DTED), mass storage systems such as the ITARS, have been developed for use in avionics applications requiring real-time access to large amounts of DTED data. Merit Technology has developed an avionics simulation that interfaces directly to DTED mass storage systems.

Under a subcontract with Hughes Aircraft Corporation, Merit Technology has developed this simulation system with a direct interface to the ITARS digital map. The system, known as the Robust Demonstration System (RDS) effectively demonstrates how ITARS digital terrain data could be used by aircraft of the future involving Terrain Following, Terrain Avoidance and SITAN avionics algorithms. This paper describes the ITARS/RDS system architecture, integration results, and areas of possible improvement.

INTRODUCTION

With the advent of Terrain Following radar, a new breed of navigation subsystems has emerged that requires accurate and detailed knowledge about surrounding terrain. Early TF systems relied entirely on elevation data measured by return signals form an onboard radar. Such systems allowed aircraft to fly safely at very low altitudes with little or no pilot intervention. The drawback of this method, however, was that a sizable radar signature was produced from the radiation emitted from the TF radar. Within the last ten years, large scale digital terrain elevation data (DTED) storage systems have become a reality and have the potential to greatly improve TF systems, as well as make feasible other avionic algorithms such as terrain avoidance, terrain navigation, and threat avoidance.

The ITARS is an airborne digital map system that stores, manages and displays large quantitates of cartographic and mission data including (but not limited to) terrain elevation data and cultural feature data. This data is maintained by the system and made available to various avionics subsystems.

The ITARS Robuts Demonstration System (RDS) provides a realistic set of avionics subsystems that exercise the ITARS's ability to manage and distribute terrain elevation, and cultural feature data. The RDS provides Navigation, Terrain Following, and Terrain Avoidance/Threat Avoidance subsystems along with an aircraft flight model, threat assessment model, RDS to ITARS communication, joystick flight controls, and a user-friendly scenario generation interface. The system is configured with commercially available components including two MicroVAXs and an IBM PC/AT.

ITARS/RDS System Overview

Functional description of ITARS

The ITARS is designed to interact with three primary avionic subsystems which require timely access to digital terrain and feature data. These subsystems are known as "users" and consist of a Navigation user, Terrain Following user, and Terrain Avoidance/Threat Avoidance user. Communication between the ITARS and these user subsystems is accomplished with messages sent over two communication paths. ITARS control, status and fault isolation messages travel along a MIL-STD 1553B data bus. Larger messages (typically output data received from the ITARS) travel along a High Speed Data Bus (HSDB). As currently implemented, the HSDB is an Ethernet data link.

As shown in Figure 1, terrain data is sent to these users in the form of Terrain Output Messages which contain elevation data points measured in meters above sea-level and are organized as North Up blocks of 16 by 16 points. For the Navigation and TF user, each block is 48 arcseconds on a side (resulting in a point resolution of 3 arcseconds). For the TA/ThA user, each block is 240 arcseconds on a side (resulting in a point resolution of 15 arcseconds). Each user receives an

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Area Load of data which consists of a series of blocks organized in a two dimensional manner. This area load contains elevation data for an area surrounding the current aircraft position. The size of the area load, as well as the rate at which it is sent to each user is specified in the ITARS User Request Message. Feature data is sent to each user in the form of Feature Output Messages. The area for which features are supplied, is the area covered by the user's terrain area load.

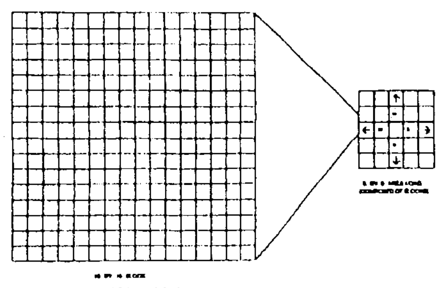

Figure 1. ITARS Terrain Output Data

Positional information is sent to the ITARS in the form of a Navigation/Aircraft State Vector Message. This message contains the position, as well as the current heading, pitch, and ground speed of the aircraft.

Threat features and waypoint information may be introduced into the ITARS with the ITARS Point Feature/Mission Data Message. This message, in conjunction with the Aircraft State Vector message, allows the pilot to designate a point on the ITARS display. Table 1 summarizes the major ITARS messages used by RDS.

Message	Type	Description
Aircraft State Vector	1553B	Provides positional information to the ITARS
User Request Message	1553B	Specifies which users are active and the size and rate of area loads
Point/Feature Message	1553B	Provide threat and waypoint information to ITARS (at any time)
Terrain Output Message	HSDB	Provides terrain data to the RDS
Feature Output Message	HSDB	Provides feature data to the RDS

Table 1. RDS/ITARS Messages

In addition to managing data, the ITARS can simultaneously generate two situation displays. These displays are full color raster views of data stored within the system, with a great deal of control possible over each image rendered. Typical formats for these displays include a perspective (out the window) view and a plan view with contour and shaded relief map options.

Functional description of the RDS

The RDS software simulates the user subsystems communicating with the ITARS and provides a scenario generation capability to define waypoints, threats, and means of flight control (autopilot or joystick). In addition, the user may specify the size and rate of area loads to be received from the ITARS. The system also includes a Route Planning algorithm which is executed if Terrain Avoidance/Threat Avoidance is enabled.

Once the scenario is constructed, waypoint and threat information is sent to the ITARS with an ITARS Point/Feature Mission Data Message. Selected user algorithms, as well as the size and desired update rates of designated area loads is sent to the ITARS with the ITARS User Request Message. An initial aircraft position (corresponding to the first defined waypoint) is sent to the ITARS with an ITARS Aircraft State Vector. After receiving these messages, the ITARS starts data transmission to the enabled user subsystems. This data is continually sent by the ITARS and is received by each user subsystem which maintains a double-buffer of received area loads. The TA/ThA area is handled differently in that it is sent on demand (i.e. when the User Request Message is sent to the ITARS) and contains data for the entire ITARS gaming area. The RDS uses this data to perform threat masking calculations as well as Terrain Avoidance/Threat Avoidance computations. When the flight simulation is started, the RDS flight model simulates the movement of an A-7 aircraft through the set of designated waypoints. As each flight position is computed, an aircraft state vector message is constructed and sent to the ITARS. To maintain an acceptable update rate, the RDS interpolates between flight model positions resulting in several aircraft state vectors for each flight model position derived.

The flight simulation is monitored with the RDS console. An aircraft symbol is displayed on the gaming region map and moves from waypoint to waypoint The display also maintains a separate window for monitoring ITARS to RDS message traffic.

Internal RDS organization

As shown in Figure 2, the user algorithms, the flight model, and the ITARS communication software are organized into separate processes coexist on two microVAXs. Each process is a self-contained program that is controlled by the main process (which also contains the flight model and route planner). Each process is highly independent of the others, with communication between each process being accomplished using Digital Equipment's DECNET software. The software is partitioned across both microVAXs according to memory, throughput and hardware interface requirements.

Figure 3 illustrates the hardware configuration of the RDS system and its relationship with the ITARS. The user interacts with the system using the IBM PC/AT keyboard and mouse. The PC monitor is a high resolution color display (1024 by 800 pixels) driven by a high resolution graphics controller (VMI-1024). During the simulation flight, the user may maneuver the aircraft using the joystick connected to the MicroVAX. In addition to the microVAX, a separate IBM PC/AT called

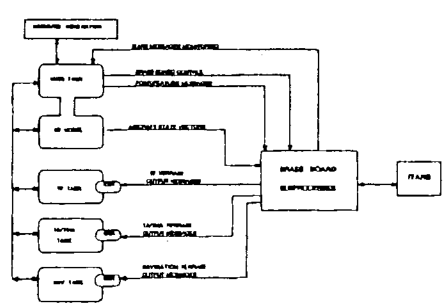

Figure 2. RDS Internal Organization

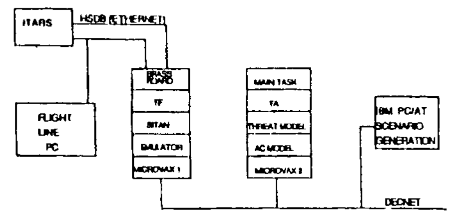

Figure 3. RDS Hardware Configuration

the flightline PC is also connected to the 1553. This PC sends ITARS Mode Control Messages and Point Feature Messages to the ITARS. Mode control messages control the ITARS mode of operation, allowing the user to alter the view on either of the ITARS displays.

All ITARS communication is handled by one program called the Brass Board process. This program provides both a 1553B and Ethernet communication link with the ITARS. Messages sent to the ITARS from the RDS are first routed to the Brass Board process via DECNET and mailbox communication links (a form of interprocess communication). The Brass Board process examines the message header to determine which 1553 subaddress the message should be sent to. The message is then forwarded to the ITARS. The Brass Board subprocess acts as the Bus Master for the entire 1553 data bus, coordinating all message traffic including mode message and point/feature message traffic originating from the Hughes flightline PC.

The Brass Board process asychronously forwards 1553B messages to the ITARS while managing incoming data from the Ethernet link. When a message is received from the ethernet link, the system performs a validity check on the message and then parses the message header to determine which user subsystem should receive the message. The message is then forwarded to the correct user via DECNET or a mailbox communication link. Each time an area load of data is received by the Brass Board process, a message is sent to the RDS main task detailing the size and type of area load received. The main task forwards this message to the PC/AT software for display on the screen. This mechanism allows the operator to monitor incoming data from the ITARS.

Each use subsystem interfaces with the Brass Board process with a set of routines known as the ITARS Data Interface Routines (IDIR) (see Figure 2). These routines

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[redacted]

From: Galus, Helen M. (LARC-B2)
Sent: Thursday, July 17, 2008 11:55 AM
To: Rotella, Robert F. (HQ-MA000)
Cc: Blackburn, Linda B. (LARC-B2); Bayer, Kathy (HQ-MC000)
Subject: File wrapper for 5,904,724
Attachments: PAT-00016 Margolin - 5,904,724 - A (L0062064).PDF; PAT-00016 Margolin - 5,904,724 - B (L0062065).PDF; PAT-00016 Margolin - 5,904,724 - C (L0062079).PDF; PAT-00016 Margolin - 5,904,724 - D (L0062080).PDF; PAT-00016 Margolin - 5,904,724 - E (L0062081).PDF; PAT-00016 Margolin - 5,904,724 - E1 (L0062083).PDF; PAT-00016 Margolin - 5,904,724 - F (L0062084).PDF; PAT-00016 Margolin - 5,904,724 - G (L0062085).PDF; PAT-00016 Margolin - 5,904,724 - G2 (L0062086).PDF

Bob,

I just realized, looking at the document names, that we actually have TWO file wrappers in our possession, one for 5,566,073 as well as the file wrapper for Margolin's second patent No. 5,904,724.

Thus, my last email incorrectly stated it was only the first half of the file wrapper, when in fact it was the complete file wrapper for 5,566,073; attached hereto is the complete file wrapper for Patent No. 5,904,724.

Sorry for the confusion. (I will resend my first email listing the documents we have with a note to include the second file wrapper on the list.)

Thanks,
Helen

Helen M. Galus
Patent Attorney
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Date: 05/16/2003

Patent Number: 5904724
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Comments: Overnight Courier

Address: Kelly Wright
NASA Langley Research Center
Office of Patent Counsel
[redacted] b(6)

Telephone Number: [redacted]

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5904724

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APPLICANTS

JED MARGOLIN, SAN JOSE, CA.

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TN

FOREIGN/PCT APPLICATIONS**********
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TN

***** SMALL ENTITY *****

Foreign priority claimed ☐ yes ☒ no 35 USC 119 conditions met ☐ yes ☒ no Verified and Acknowledged TN Examiner's initials	AS FILED →	STATE OR COUNTRY	SHEETS DRWGS.	TOTAL CLAIMS	INDEP. CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
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ADDRESS

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
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TITLE

METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

U.S. DEPT. OF COMM./ PAT. & TM—PTO-436L (Rev 12-94)

PARTS OF APPLICATION FILED SEPARATELY

Applications Examiner

NOTICE OF ALLOWANCE MAILED

AUG 24 1998

Assistant Examiner

CLAIMS ALLOWED	
Total Claims	Print Claim
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TAN Q. NGUYEN
PATENT EXAMINER
ART UNIT 3614
Primary Examiner

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7	7	3 and 4

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08/587731

PATENT APPLICATION

08587731

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CONTENTS

Date Entered or Counted		Contents	Date Received or Mailed
	1.	Application ______ papers.	
	2.	Information Disclosure Statement	1-17-96
7-18	3.	rej 3 month	7-23-97
	4.	INTERVIEW SUMMARY	9-12-97
10-5-97	5.	Amdt A	9-11-97
10-14	6.	Letter	10/14/97
10-23	7.	Letter Response	10-21-97
11-21	8.	rej 3 mos w/Att	11-28-97
	9.	IDS	2 March 1998
	10.	Amdt B	2 March 1998
5/4	11.	Final Rej 3 mo	MAY - 4 1998
	12.	Req for Recon	9 July 1998
7/24	13.	Advisory Action	JUL 2 4 1998
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INDEX OF CLAIMS

Claim Final	Claim Original	07/18/97	11/20/97	05/01/98	07/23/98	08/20/98			
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SYMBOLS

✓ .... Rejected
= .... Allowed
- (Through numberal) Canceled
\+ .... Restricted
N .... Non-elected
I .... Interference
A .... Appeal
O .... Objected

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