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New Computer Techniques For Tracking Systems

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NEW COMPUTER TECHNIQUES FOR TRACKING SYSTEMS

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ABSTRACT

New computer techniques applied to tracking systems provide substantial improvements in system performance. Active sensors employ two separate control loops, one for rf error signal processing, and the other for mount drive. Response times, bandwidth and other parameters are optimized to provide desired performance characteristics.

INTRODUCTION

Conventional methods of active sensor tracking employ a basically unstable system requiring it to be off the line between sensor and target before an error signal occurs and a drive signal is generated to correct the misalignment. Predictive pointing systems utilizing the concepts of adaptive control theory, precise mount calibration to stellar references with telescopes, accurate timing using cesium beam standards, and extensive use of a digital computer for a variety of functions and operating in real time, make up the fundamental building blocks of a new tracking technology.

DISCUSSION

Calibration to celestial references is achieved by maintaining a star table within the computer and with suitable updates, point the mount to the azimuth and elevation position at which the star should be located. The differences in azimuth and elevation are measured while moving the mount at sidereal rates to continuously point at the star. This is illustrated in Figure 1 which shows the results obtained when the mount is not level. Droop and "non-orth" information is also entered into the computer based on calibration data taken.

Precise mount elevation and azimuth angular position information is obtained from high resolution encoders. These are mounted on the respective shafts and encoder bias readily handled electronically in the computer. Currently used encoders have photographically etched masks with lamps and detectors to provide arc sector information. The mount is driven by a digitally simulated Type II servo system.

Timing is obtained from a highly stable cesium beam standard oscillator. A time of day clock is driven to provide accuracy to within microseconds of universal time. The range machine and computer interrupts are also slaved to the master oscillator.

The computer can be a miniprocessor with sufficient interrupts, memory, and computational capability to provide pointing information. Figure 2 shows refraction phenomena based on differing effects of varying density in atmospheric lasers for light as compared to microwave radiation.

Data on current weather conditions are entered into the atmospheric model in the computer to account for these differences.

Figure 4 shows the basic mount control system. An initial vector sent to the sensor is transformed by the computer to the mount coordinate system and a desired position signal generated. This is compared with the actual position of the mount and a different signal results in mount drive to zero the difference.

Figures 5, 6, and 7 show results taken from the first series of tests with the TAA-2 sensors. OVER/UNDER is a well designed mount containing two telescopes and is used as a theodolite to evaluate tracking accuracy. The TAA-2 is a large dish 80 feet in diameter providing a narrow beam high gain antenna. The mount and support structure shows considerable flexing as the load distribution changes during track. It is not a precision mount and represented a significant challenge in mounting encoders, calibration, and finally pointing it accurately toward targets both thrusting and on orbit. The results show that although it was not able to perform as well as OVER/UNDER in these early tests, the target stayed well within its beam width and it pointed smoothly during the duration of the test. This data is summarized in Table 1.

CONCLUSIONS:

The results show a unique capability to point sensors using direct connections of computer to mount control systems. Distinct advantages result when similar drive systems are used on active sensor mounts as well as on passive systems. Smooth track provides smaller rf signal level in variations, hence decreased tracking noise.

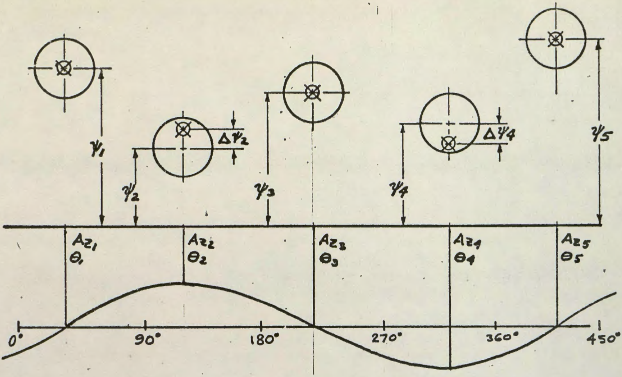


Figure 1. Calibration to Stellar References.

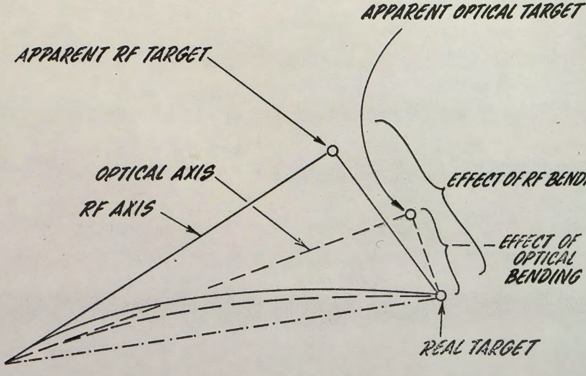


Figure 2. Optical and RF Refraction.

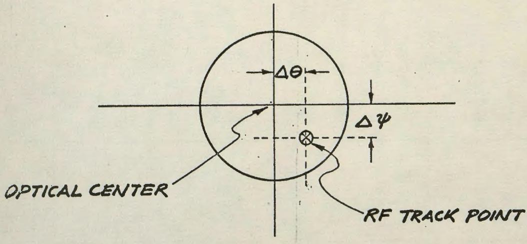


Figure 3. Differences Between Optical and RF Track Point.

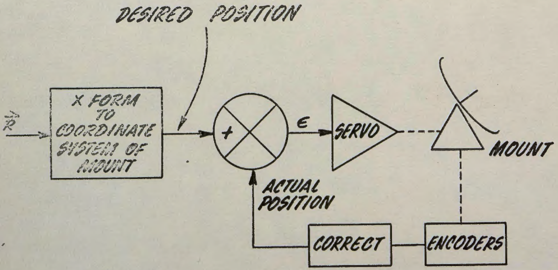
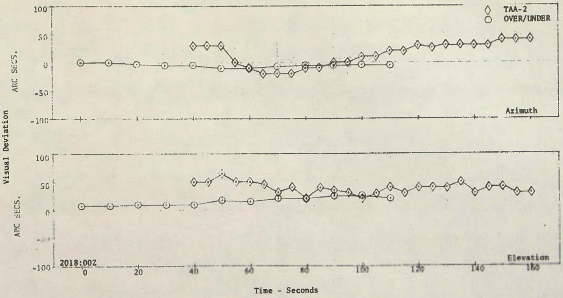


Figure 4. Basic Mount Control System.

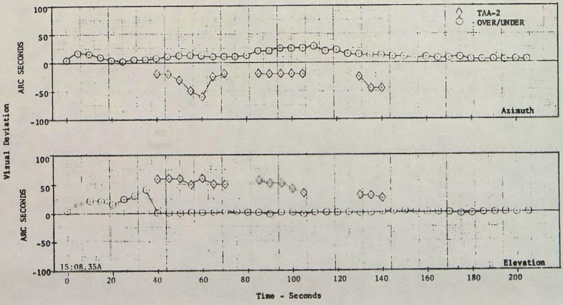
Driving Radar	3.13
Object	1381
Date	27 Jul 72
Rise Time	2011Z



Visual Deviations of TAA-2 and OVER/UNDER With Simultaneous Drive.

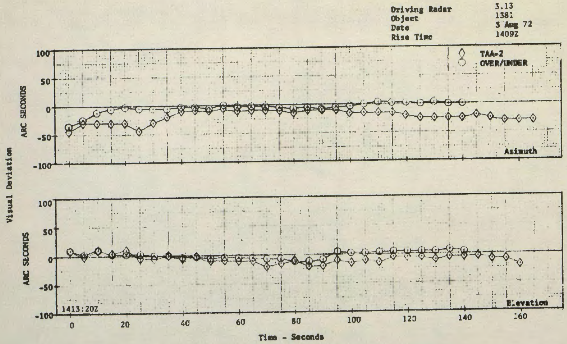
Figure 5. Visual Deviation.

Driving Radar	3.13
Object	1085
Date	4 Aug 72
Rise Time	1505Z



Visual Deviations of TAA-2 and OVER/UNDER With Simultaneous Drive.

Figure 6. Visual Deviations.



Visual Deviations of TAA-2 and OVER/UNDER With Simultaneous Drive.

Figure 7. Visual Deviations.

DATA SUMMARY: Means of Absolute Magnitudes; Deviations of Image of Tracked Object From Telescope Cross Hairs

Driving Radar	TRACKED OBJECT #1085						#1381					
	PASS		DATA CHANNEL ΔA DRIVEN SENSOR		ΔE DRIVEN SENSOR		PASS		DATA CHANNEL ΔA DRIVEN SENSOR		ΔE DRIVEN SENSOR	
	Date	Rise Time-Z	TAA-2	O/U	TAA-2	O/U	Date	Rise Time-Z	TAA-2	O/U	TAA-2	O/U
3.13	27 July	1830	29.8(21)	9.3(10)	27.6(21)	6.2(10)	27 July	2011	21.4(25)	4.9(12)	38.6(25)	15.5(12)
	27 July	1911	22.1(21)	11.5(13)	25.5(21)	5.1(13)	28 July	1821	16.4(14)	10.0(14)	16.4(14)	4.1(14)
	26 July	1853	28.1(21)	5.5(15)	27.4(21)	2.9(15)	3 Aug	1228	22.9(21)	6.2(30)	41.2(21)	6.2(30)
	3 Aug	1523	30.7(14)	6.8(14)	33.6(14)	11.2(14)	3 Aug	1409	20.4(34)	27.5(29)	15.3(34)	4.9(29)
	4 Aug	1505	26.8(16)	11.6(42)	46.0(16)	4.5(42)	4 Aug	1038	45.2(58)*	6.0(43)	61.0(58)*	0.5(43)
	4 Aug	1645	19.5(10)	5.5(18)	40.5(10)	2.4(18)	4 Aug	1542	33.3(18)	10.6(33)	31.9(18)	8.4(33)
GRAND MEAN			26.8(103)	9.0(112)	32.1(103)	5.0(112)			22.7(112)	11.1(161)	28.2(112)	5.3(161)
0.13	3 Aug	1201	32.9(42)*	29.4(42)*	32.9(42)*	11.9(42)	2 Aug	1559	50.0(11)	7.2(26)	40.0(11)	0.92(26)
	4 Aug	1143	28.8(25)	5.9(41)	17.6(25)	12.2(41)	3 Aug	1550	28.1(16)	11.0(34	32.5(16)	9.5(34)
							4 Aug	1400	45.6(16)	4.9(37)	12.2(16)	13.6(37)
							4 Aug	1219	38.3(24)	16.5(33)	41.9(24)	13.4(33)
GRAND MEAN			28.8(25)	5.9(41)	17.6(25)	12.0(83)			39.5(67)	9.9(130)	32.3(67)	9.9(130)

Units: Arc Seconds

*Not included in the grand mean.

( ) = Number of Observations

Table 1. Data Summary.