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AN EXPERIMENT TO DETERMINE THE FEASIBILITY OF HOLOGRAPHIC ASSISTANCE TO FINGERPRINT IDENTIFICATION

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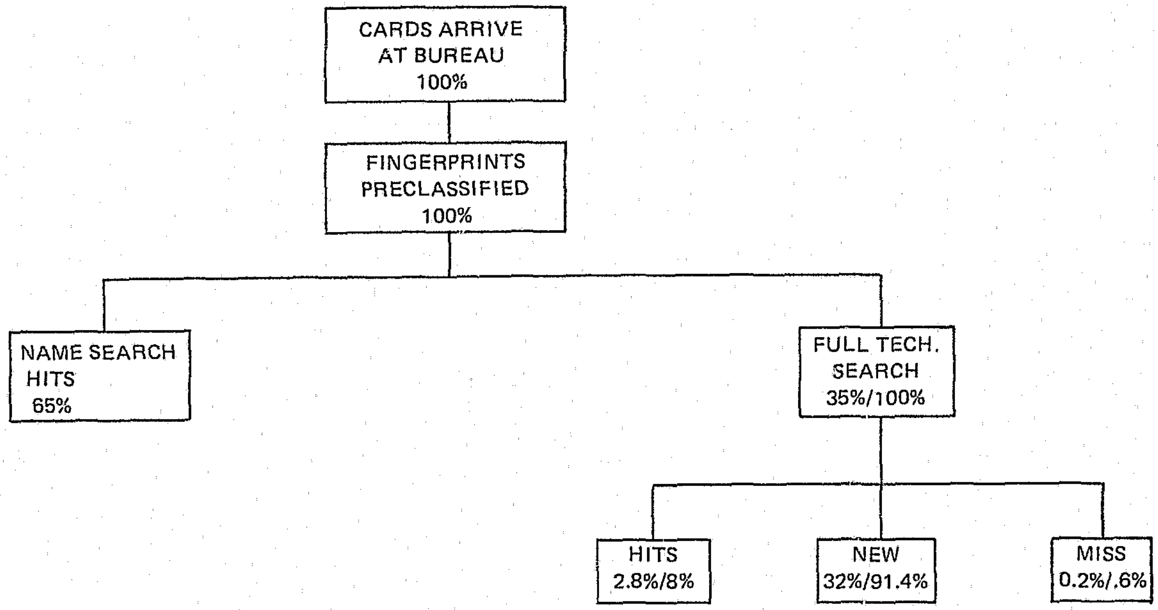
This paper describes a recent experimental investigation into the feasibility of providing technological assistance to state identification bureaus in their task of identifying persons on the basis of full set fingerprint impressions. This investigation was carried out by the Project SEARCH Technology Committee during early 1972. A full description of the experiment and its findings is published in *Project SEARCH Technical Report No. 6*, entitled "An Experiment to Determine the Feasibility of Holographic Assistance to Fingerprint Identification" dated June 1972.

Before going any further, it is important to point out that this feasibility experiment did not address itself to the question of holography as part of a latent fingerprint identification system, such as those used to process prints taken at a crime scene. That application has a special set of problems associated with it: the prints taken from the crime scene may be smudged, partially missing or obscured, combined and confused with other prints from the same person or different persons who were in the same area, and on the other hand are usually compared against much smaller libraries of master prints. Because of these special circumstances, it was determined that the latent print application could not easily be combined in a feasibility experiment with the identification bureau application.

While still focusing on the title of this paper, one might properly ask why we limited our attention to holographic assistance to the identification process, rather than allowing ourselves a broader scope such as "technological assistance" or "electromechanical assistance" to the identification process. Our reasons for this self-imposed limitation of scope are threefold: first, the potential techniques which might be appropriate for assistance in this area are so broad and so diversified that it would have been extremely difficult to design an experimental configuration which would adequately have tested all possible methods, especially within the time constraints we imposed upon ourselves and the financial constraints imposed on us by LEAA. Second, other research and development programs presently under way have addressed themselves to other possible technologies. In particular, the FBI is developing through the services of Cornell Aeronautical Laboratory a fingerprint identification method which relies on computerized processing of a digital representation of fingerprints. The New York State Intelligence and Information System is similarly engaged in development activities concerning computerized processing of fingerprint images. Thus it seemed reasonable to us to intentionally limit our scope in an effort to focus our resources on one possible technological avenue, namely holography, and rely on other programs to investigate other such avenues. Third, by the time we initiated our project, holography had reached a state of technical maturity and public notice sufficient to argue that someone had to take this possibility seriously and study it in an effort to focus further development efforts, and especially to provide guidance to state identification bureau administrators concerning possible avenues of development and procurement in future years.

In order to establish the operational context in which our experiment was set, I would like to review briefly with you the state identification bureau identification process (Exhibit 1). A fingerprint identification inquiry of the type we are interested in begins with the arrival of a fingerprint card at the state identification bureau. The fingerprint card is 8" x 8", contains 20 inked fingerprint impressions, 10 flat impressions and 10 rolled impressions. In the analytical model which we developed for comparative analysis purposes during this project, we assumed approximately 20,000 such inquiry cards arriving monthly at the state identification bureau; this is typical of a medium-size state operation. All of these cards received an initial fingerprint preclassification and proceed to a name search routine which, by the way, uses not only the person's name but his fingerprint preclassification, identifying numbers, and physical



TYPICAL STATE IDENTIFICATION BUREAU PERFORMANCE

EXHIBIT 1

descriptors in an attempt to narrow down the search from the million or million and a half fingerprint cards on file to perhaps two or three candidates, which can then be quickly checked visually and an identification made. In the typical identification bureau represented in our analytical model, approximately 65% or 13,000 identifications per month are in fact made on the basis of such a name search routine.

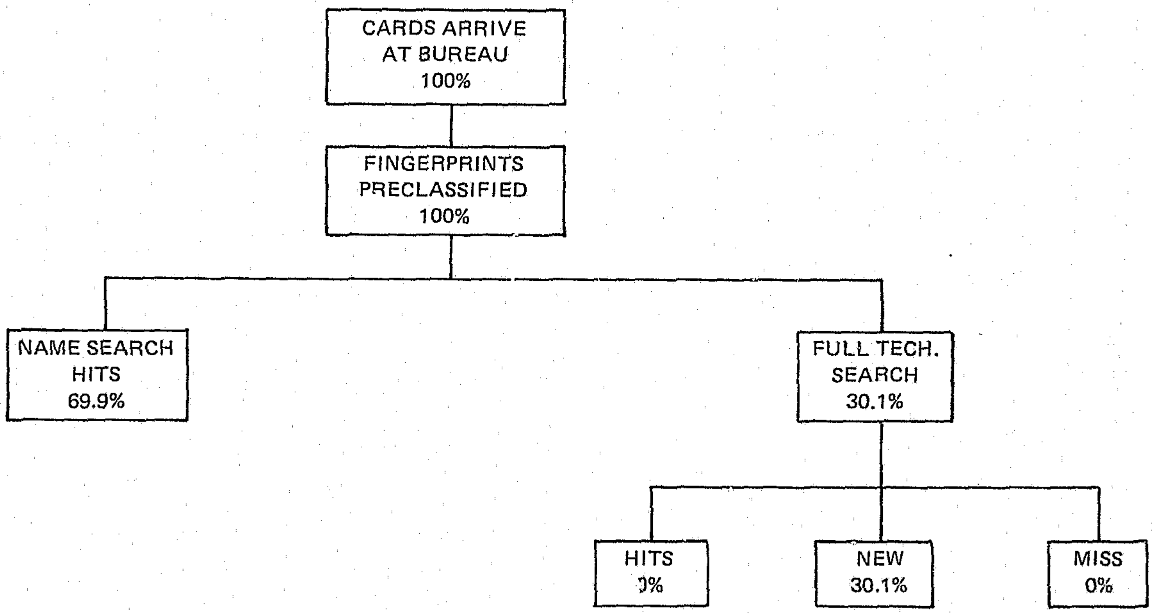
The 35% or 7,000 cards per month which do not result in an identification on the basis of name search technique are submitted for full technical search of the fingerprint file. The file, consisting in our model of 1.5 million fingerprint cards, is divided into subfiles on the basis of the Henry fingerprint classification system, which allows for 1,024 major subcategories, and further subdivision in larger subfiles.

Shift our base now so that the 7,000 cards per month submitted for full technical search are considered to be 100%, we find in our model that approximately 91.4% of the cards represent first-time offenders within the bureau, 8% are identified as previous offenders from the file, and 0.6% should be identified as previous offenders but are missed for various reasons.

One may wonder at this point why we are concentrating our efforts on the full technical search process, rather than on the name search which after all handles 65% of all the cards. The first answer to this question lies simply in pointing out that the 65% of the cards processed successfully through name search account for nothing like 65% of the cost or effort of the identification bureau, but probably closer to 20%. The remaining 80% of the cost of the identification bureau is borne by the full technical search process. Therefore, the opportunities for cost reduction lie primarily in cost reduction of the technical search process itself.

One still might argue that substantial economies could be obtained by increasing the effectiveness of the name search, so that fewer cards would have to be submitted to the full technical search process. The next chart (Exhibit 2) shows that even a "perfect" name search technique would reduce the workload of the technical search function only insignificantly, from 35% of full bureau input to 30%. Thus we were led to the conclusion that concentration in the full technical search area would be in the best interests of both technology and the operational needs of state identification bureaus.

The major participants in this experiment included first of all the Technology Committee of Project SEARCH, which acted as a steering committee for the project. Under the Chairmanship of Al Kwiatek of Pennsylvania, the committee included Joel Tisdale of Texas, Andy Shehan of Georgia, Bill Reed of Florida, Dick Plants of Michigan, Jim Paley and Paul McCann of New York, Gary McAlvey of Illinois, Roy Lewis of California, Ron Johnson of Massachusetts, Joe Barry



STATE IDENTIFICATION BUREAU PERFORMANCE WITH "PERFECT NAME SEARCH"
EXHIBIT 2

of New Jersey, and Ron Allan of LEAA. Paul McCann was Chairman of the subcommittee which actually controlled this project.

Administrative staff services to this project were provided by the California Crime Technological Research Foundation in the person of Doug Roudabush and George Buck. Technical staff services were provided by Paul Wormeli, Howard Hayes, and myself as principal investigator for the technical staff, all from Public Systems incorporated.

Finally, three corporate participants actually conducted the experiment, each using a holographic configuration developed by that corporation. Dr. C. E. Thomas acted as principal investigator for the KMS Technology Center. Jerry Belyea was principal investigator for the McDonnell Douglas Electronics Company, and Dr. Donald McMahon was principal investigator for the Sperry Rand Research Center.

The experiment itself was conceptually very simple. The library of 10,000 fingerprint cards was assembled, and names and other identifying information were removed from each card in order to preserve the privacy of the individuals concerned. These cards were provided by the California Bureau of Identification from cards just purged from its master library. The library was assembled in such a way that the distribution of cards with respect to Henry fingerprint classification was representative of the distribution of classifications found in the master California files, at least for the 10 most frequently occurring Henry classifications which together account for 55% of the entire file.

Next, a set of 600 test cards was assembled, again from the California Bureau of Identification, and these test cards were divided into three sets: the first set or "tuning set" of 100 cards was given to the corporate participants along with the 10,000 library cards in order to allow them to pretest and adjust their holographic equipment; the second or primary test set of 100 cards was given to each of the three corporate participants at the time of test administration; the third or secondary test of 400 cards was given to those two corporate participants (KMS Technology Center and Sperry Rand Research Center) which had indicated a willingness to undertake this optional portion of the test procedure.

The experiment was configured as an openended experiment. That is, some cards in the test set did not have matches in the master library, while others did. Such an openended design is basically more difficult than a "closed experiment in which the participants knows ahead of time that each test card has a match in the library, and are never required to make "no match" decisions during the experiment.

On the other hand, multiple responses were allowed for each test card, up to a limit of 10 responses per test inquiry card. This reflects the belief of the committee that a human being will always have to be available at the end of the process to inspect visually the card claimed as a match by the holographic system; as long as he is there it will not unduly delay the process nor increase process costs if he is required to look at a relatively small number of possible candidates.

The individual test cards were provided to the corporate participants (in the form of transparencies made to the quality standards specified by each participant) by a project representative, and all subsequent activities by the participants were monitored. The official monitor for each participant recorded the time required to make the holographic comparisons against the library card images, and recorded the responses by each participant by a sequence number written on both the test cards and the library cards. The monitor was not aware during the experiment of the sequence numbers which represented correct matches, and simply brought the data back for later analysis.

When the data was returned, analysis began. It had originally been intended to perform a relatively detailed analysis of time required for various portions of the comparison process. After an examination of the equipment configuration used by the corporate participants, however, it was determined that equipment was of such a prototypical nature that substantial changes in operating times could be achieved with relatively minor engineering changes to the equipment, so that effort expended in determining processing times could be better spent focusing on the accuracy performance achieved during the experiment.

As mentioned previously, each participant was allowed to list up to 10 candidates, in rank order of preference, for match between a test card in the library. In any case where the correctly matching card was included on a list of candidates, the response was scored as a correct match, and the rank order of the correct response was tabulated. If in fact there was no matching card in the library and the respondent correctly listed this by showing no candidates, the response was scored as a correct dismissal. If in fact there was no matching card in the library but the participant did provide one or more candidates for visual inspection, the response was scored as a false match. If on the other hand there was truly a matching card in the library but the respondent listed no candidates for visual inspection, the response was scored as a false dismissal. Finally, if there was a match in the library and the respondent listed candidates for visual inspection, but the true matching card was not on the list of candidates, the response was scored as a mismatch.

Of the three types of error responses a false match is by far the least serious error type, since visual inspection of the candidates will reveal that a match does not exist, and the total man-machine system response will then be a correct dismissal. On the other hand, false dismissal and mismatch responses provide no opportunities for the human portion of the total system to correct the error, so these are serious errors.

The next chart (Exhibit 3) shows the results achieved during the primary experiment, involving 100 test cards processed against that portion of the 10,000 card library having the same Henry classification as the test card. The three vertical divisions of the chart refer to the three corporate participants, namely KMS Technology Center, McDonnell Douglas Electronics Company, and Sperry Rand Research Center. The first three rows refer to those responses which are possible when a match in fact exists in the library, while the lower rows refer to those responses which are possible when no match in fact exists in the library. For each response type two numbers are tabulated, first the actual number of trials during the primary experiment that resulted in that response type, and second a so-called conditional percentage, which merely means that the number of that response type is divided by the maximum possible number; hence for correct match, false dismissal, or mismatch, the number is divided by 73, which is the number of test cards in the primary test set which actually had matches in the master library.

First, notice that of all the cards submitted for test, only one was not processed by a participant. This clearly shows that the holographic process is capable of processing the normal spread of fingerprint impression quality encountered in a state identification bureau, since both the test set and the library cards were chosen to be representative in quality of those received during normal operations. Second, we re-emphasize our statement that, from a total system viewpoint, correct dismissal and false match responses are in a sense equivalent, since we trust the human being at the end of the stream to sort through up to 10 candidate cards and change the false matches to correct dismissals, with only the expenditure of a relatively small amount of time.

Thus, the real import of this chart is in the first row, where we find that the correct match rates of the three participants ranged from 88 to 96%. This compares to our estimate of the performance of an existing good manual state identification bureau operation, which would exhibit a correct match

	KMS		MDEC		SRRC	
	NUMBER	CONDITIONAL PERCENT	NUMBER	CONDITIONAL PERCENT	NUMBER	CONDITIONAL PERCENT
CORRECT MATCH	64	88	70	96	64	88
FALSE DISMISS	4	5	2	3	2	3
MIS-MATCH	5	7	1	1	7	10
CORRECT DISMISS	8	42	13	68	8	42
FALSE MATCH	10	53	6	32	11	58
NON PROCESSED	1	5	0	0	0	0

PRIMARY TEST RESULTS

EXHIBIT 3

rate of approximately 93%. Since the completion of the experiment, in fact, I have been informed that another of the corporate participants has changed the matching algorithm used, and is prepared to demonstrate accuracy rates above the 93% level.

One might think, then, that the feasibility of holography as a technological assistance to state identification bureau fingerprint identification function has been conclusively proved. One and possibly two of the corporate participants, after all, have demonstrated on a statistically valid experimental basis the ability to meet or exceed the accuracy standards presently obtained in state identification bureaus. Unfortunately, while accuracy is critical, and the results of this experiment mark a great step forward in this area, there is more to be said before feasibility can be assured.

I mentioned earlier the fact that processing times were not considered particularly valid during the experiment because of the prototypical nature of the equipment configurations used. Nevertheless, we cannot ignore the fact that processing times were, in general, not merely longer than manual systems but longer than manual systems by several orders of magnitude. Again, however, I must report that subsequent to the conclusion of the experiment two of the corporate participants have, through internal development efforts, substantially decreased the processing times required.

Finally, as I mentioned earlier, holography is not the only form of technological assistance available to state identification bureau operations. Other programs presently under way use digital processing of various forms to provide the same functional service. Thus we find that the state identification bureau identification process, so long conducted without any technological support, now finds itself in a position of being wooed by alternative technologies, none yet ready for operational implementation but all showing great promise of providing assistance in this difficult and important area of criminal justice. We have preserved the test cards and library used in our experiment, and hope that, at the appropriate stage of development, these other technologies can be measured as has holography.

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