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October 7, 1965

Proposal ESU 65-88

Gentlemen:

We feel that techniques developed at [redacted] could be directly applied to your needs for automatic focusing of certain optical instruments, as discussed in several previous meetings and as very briefly outlined in your document, "Objectives for an Automatic Focusing System."

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We would like to propose here a preliminary study phase during which time we can learn more about your specific needs and can conduct a number of experiments to determine whether we can indeed build a suitable "front end" sensor to meet your specific requirements. Should the result be encouraging, as we hope and expect, then we would propose a second study to take a specific piece of equipment and modify it for complete automatic control.

The basic technique that we propose is outlined in the first attachment, Item A, entitled "Optical Detector for Objects Within an Adjustable Range." In this approach, the object space is imaged on the face of a wide-area non-linear photocell, which vibrates in the direction of the optic axis. By sensing the phase of the fundamental component in the output signal, and also certain harmonic content, it is possible to determine the state of focus, or defocus, of the system. The series of photographs in Fig. 1 of Item B (entitled "Techniques for Optically Determining Distance, Direction and Shape") shows the results for a three-dimensional "real world" object space involving a person approaching the optical system, which is fixed-focused for 6 feet. Note the change in waveform as the front "surface" of the person approaches and passes through the six-foot distance.

The successful results with three-dimensional object space, and with an optical system designed to operate over a considerable range of focus distances, makes us confident that we could design a system to operate on basically two-dimensional objects (photographic film) whose object distance varies over only a relatively small range.

There is little question then about designing a system for automatic focus control, based on this technique. The primary questions revolve about meeting the exact specifications. To answer these questions we need considerably more information about the specific equipments involved, and we must also engage in a certain amount of experimentation. Based on our present knowledge of the requirements, however, we feel that we could design a system which in both resolution and frequency response is such that overall performance is not limited by the automatic focusing system itself.

We might note at this point that we are also actively engaged in study of the human focus system. This research was motivated by the finding of an axial vibration in the human lens system. Our previous experience with range finding, and with axial vibrations, led us to speculate on the possible role of this vibration in the human focus system. Under NASA sponsorship we studied the problem and have now developed a model for accommodation control that has stimulated a new series of experiments in accommodation control. We are presently developing quite versatile facilities for continuously monitoring accommodation magnitude and eye movements. (Our model predicts considerable interaction between eye movements and accommodation control.) These results may in fact be quite important to performance of your overall system, in which operators must maintain good focus and acuity while scanning moving patterns.

For the specific problem at hand, we propose a six-month study to carry out the research and report results. We visualize the following program:

(1) Approximately one month for studying the specific requirements and for planning a specific set of experiments.

(2) Four months for performing laboratory experiments. The key points to be experimentally studied during the laboratory phase of the project include:

   (a) Selection of photocell that will best meet the requirements of resolution, speed of response, and light sensitivity.

   (b) Determination of the best method (such as beam splitting) of incorporating the focus detection unit with the optical paths of the various equipments under consideration.

   (c) Determination of means to accommodate the focus detection with the wide range of image magnifications used in some of the equipments.

(3) A month to evaluate the results and make specific recommendations.

We could initiate work on this program as of January 1, 1966. The projected cost is outlined in the attached Appendix Item C. The biographies of professional personnel who would be mainly concerned with the program are attached as Item D.

It is requested that any contract resulting from this proposal be written on a cost-plus-fixed-fee basis.

This proposal will remain in effect until January 1, 1966. If consideration of the proposal requires a longer period, the Institute will be glad to consider a request for an extension of time.

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Very truly yours,

[redacted]

Control Systems Laboratory

Engineering Sciences and Industrial Development

Next 21 Page(s) In Document Exempt

Approved For Release 2003/06/11 : CIA-RDP78B04770A002000030004-4