FEDERAL AVIATION ADMINISTRATION
AAR-100 (Room 907)
800 Independence Avenue, S.W.
Washington, D.C. 20591

Tel: 202-267-8758
Fax: 202-267-5797
william.krebs@faa.gov

July 28th, 2004

From: Vertical Flight Human Factors Program Manager, ATO-P Human Factors R&D
To: Vertical Flight TCRG

Subj: VERTICAL FLIGHT HUMAN FACTORS THIRD QUARTER '04 REPORT

Ref: Vertical flight human factors execution plans (http://www.hf.faa.gov/vffunded.htm)

1) Each project is listed below.

   a) Night Vision Goggle Lighting Requirement

   The researcher delivered three NVIS evaluation kits to ASW. The primary study comparing NVIS lighting acceptance/rejection using visual acuity assessment vs. NVIS radiance assessment was designed and conducted. The researcher is analyzing the results and plans to deliver the final report in a few months.

   All available information indicates the project is on track.

   b) Simultaneous Non-interfering Operations - Quantify VFR Navigation Performance.

   NASA Ames (Eye Tracking Task): The main accomplishment for this period was estimation of head pose from the "face camera" sequences (see fig. 1). This task was complicated by the fact that the camera used to obtain these sequences was mounted in a way that permitted significant vibration at a frequency near 60 Hz (the vertical scanning frequency), resulting in time-varying vertical distortions of the images. A method was developed to correct these distortions based on tracking stationary background features in order to estimate the motion of the camera. The motions were well-fit by sinusoids, and the resulting model of the motion allowed geometric correction of intermediate pixels.

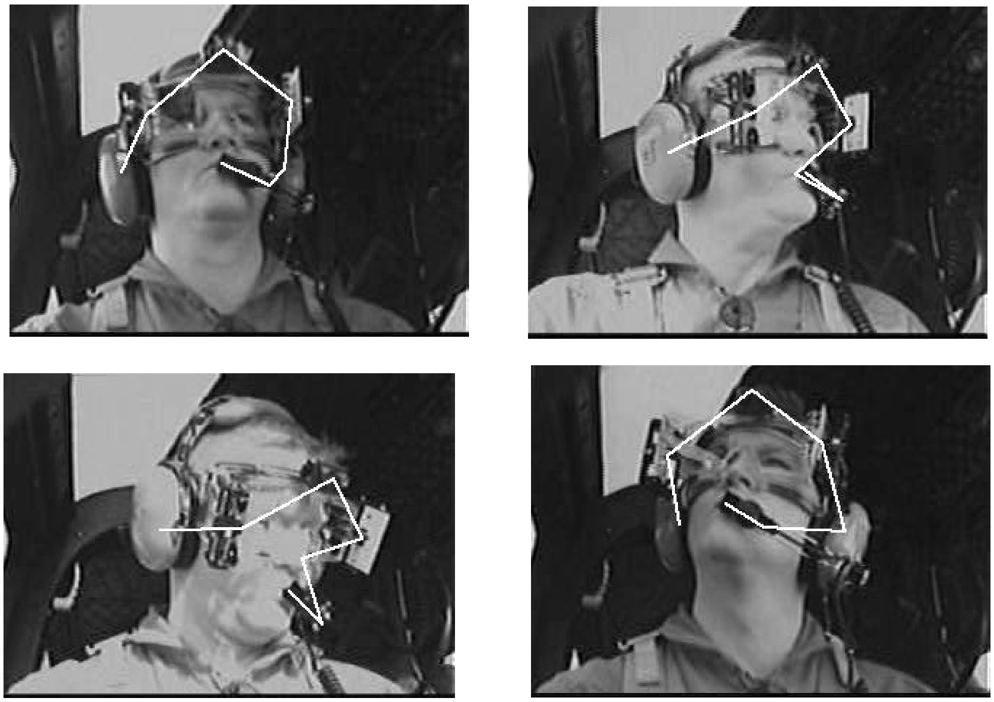

Figure 1: Visualization of head pose estimation using “bent coat-hanger : the white line segments overlaid on these images are projections of a three-dimensional structure; the pose of the structure is adjusted automatically so that the vertices coincide with features in the images.

Determination of head pose was accomplished by a combination of manual and automatic procedures. A set of conspicuous features was identified, for example the earphone, microphone, eye camera, etc., and these features were indicated by hand in a set of representative frames (around 100). An approximate model of the three-dimensional structure was obtained from a pair of images (frontal and profile views). The approximate structure obtained in this way was iteratively refined as follows: using this initial structure, the pose of the model was adjusted to optimize agreement between the predicted and observed feature locations. The poses obtained in this way were then fixed and the model structure was adjusted to improve the fit to the data. This cycle of alternate adjustment of pose and model estimates was repeated several times, resulting in a stable solution. (Although this procedure is in general inferior to simultaneous joint optimization of pose and structure, it is more tractable computationally, and in this case seemed to produce correct results.)

A principal components analysis (PCA) was performed on the set of training images for each feature, resulting in a reduced-dimensional representation of the appearance of each feature as a function of pose. These data allowed us to generate an inverse mapping relating the appearance of each feature to pose. To process a new image, the previous appearance was correlated with the image, and the location of the best match was identified. Then the image content at the identified location was projected onto the basis identified by the PCA.

The resulting coefficients were then mapped to an initial estimate of pose. (Note that this results in an independent estimate of pose for each feature, and does not consider the spatial relationships between the features.) The final estimate was obtained by fitting the 3-D structure (described in the preceding paragraph) to the feature locations.

The estimates of head pose obtained in this way were used to control a mosaicing algorithm which was applied to the images from the head-mounted scene camera. Under the assumption that the head mounted camera is subject to rotation only (or that any translations are small compared to the distance to the scene elements), then accurate estimation of head pose should lead to perfect reconstruction. Misalignment of the registered images can be related to the error in the pose estimation process, and give us a direct way to visualize the resulting error in gaze estimation (see figure 2). Note that the mosaic shown in figure 2 was constructed using only the head pose estimates from the face camera images; current work is improving this by using the content of the scene camera image itself to improve the registration.

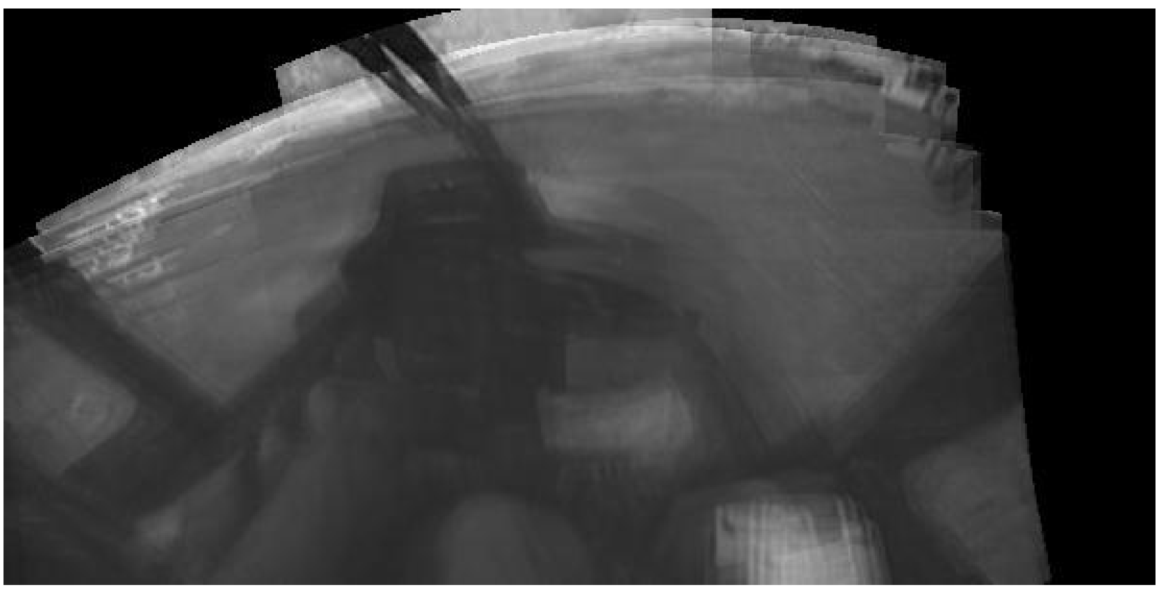

Figure 2: Mosaic image constructed by warping images from the head-mounted scene camera using only parameters obtained from analysis of the face camera images. If there were no translational movements of the head-mounted camera, and given error-free estimates of the head rotation, this should result in perfect registration of the elements of the cockpit. The mis-registrations which are visible in this image result from both errors in the estimation of head pose and violations of the assumption of pure rotational motion. The amount of misregistration can be interpreted as the maximum achievable gaze tracking precision using these data.

Naval Postgraduate School (NPS) (Virtual Model Task):

Task 7. Conduct simulation using multiple SNI scenarios provided by ATO-P Human Factors R&D

- Human performance and modeling data
- Not started. Awaiting ATO-P Human Factors R&D input.

Task 8. Complete analysis and write report

- Report specifying the minimal RNP value for various SNI scenarios
- Not started. Follows task 7.

Indications are that there are risks to the activity being completed as planned. NASA Ames eye tracking analysis should be completed by December 2004. NPS simulation will begin without task (c) input. ATO-P Human Factors R&D will request NPS to collect PVFR data based on October 2003 flight notes.

c) Rotocraft Precision Visual Flight Rules Simultaneous Non-Interfering Human Factors Project.

ATO-P Human Factors R&D awaiting ASU's award of contract.

Indications are that there are risks to the activity being completed as planned. The September 27th, 2002 execution plan stated that the final report would be delivered by January 15th, 2005. After the contract is awarded, a new delivery date will be announced.

William K. Krebs