

Determination of Frame Rate Requirements for Videopanorama-based Virtual Towers using Visual Discrimination of Deceleration during Simulated Aircraft Landing: alternative analysis

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Introduction

Recent proposals for new air traffic control have suggested that advanced digital video technology may remove the need for air traffic controllers to be present in airport towers. In the future airport traffic in particular at small airports may be controlled from a remote location without the need for a physical tower building (Fürstenau & Schulz-Rueckert 2010). Since preliminary investigation of the role of visual features in tower operations has shown that their general function is to support *anticipated separation* by allowing controllers to predict future aircraft positions (Ellis & Liston, 2011), we have begun to investigate the effects of video frame rates (FR) on the decelerations cues used to anticipate whether a landing aircraft will be able to brake on a runway, as if to make a turn off before the runway end. Frame rate is an important system specification because it directly impacts the required communication bandwidth which can easily exceed 100 MB/s.

Initial analysis based of a remote tower simulation study showed that the discriminability index d' decreased with FR (Ellis et.al. 2011). Extrapolation via a model-based exponential fit indicated FR = 40 – 60 Hz to be required for minimizing decision error. Here we present an alternative analysis based on the non-parametric discriminability index A which may be thought of as the area under the Receiver Operating Characteristc (ROC) curve.

Experiment

Thirteen active air traffic controllers viewed high dynamic-fidelity simulations of landing aircraft and determined whether they would stop before the end of the runway, as if to be able to make a runway turnoff. Three frame rates were used: 6, 12, and 24 fps. The frame rate that would be needed to produce asymptotic performance was estimated from a model fit to perceptual discriminability (A) of the condition in which the aircraft would stop before the end of the runway. The three matched subject groups were used in an independent groups, randomized block design (blocks of 10) in which three different landing decelerations were used to produce 60 landings to the west on the Braunschweig airport's Runway 26. Each group was assigned to one of the three video frame rate condition. The approaches were all equivalent nominal approaches for an A319 aircraft. All landings shared the same touchdown point ~25 m beyond the threshold. The re-

maining distance for the A/C to come to a stop was ~1500 m. The initial simulated ground decelerations were 1.33, 1.76, 2.39 m/s^2, which decreased nearly exponentially to a final value at the stop position on the runway.

Results and Discussion

Our exponential model based analysis of discriminability index A is shown in Fig.1 in qualitative agreement with results of Claypool (2007) who investigated the hit rate in a 1st-person-shooter video game. It suggests a required FR ≥ 30-35 Hz, but definitive recommendations require further testing at a higher FR. Index A can be argued to be bias-free, independent of user criteria and primarily a function of the task requirements and perceptual noise. Together with the data based linear extrapolation with A = 1 at ca. 35 fps this analysis suggests somewhat relaxed FR requirements as compared to the d' analysis.

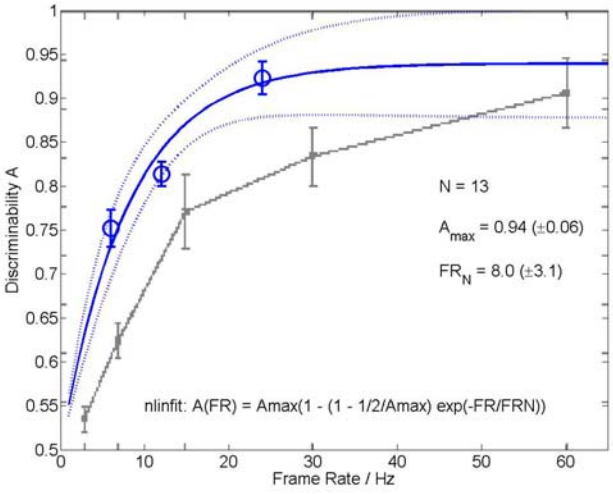

Fig.1: Exponential model based extrapolation (solid trace) of the measured (o, stderr) discriminability A (with 95% regression prediction confidence intervals, dotted curves) of landings on which aircraft are predicted to stop on the runway from those on which they do not. Grey trace with error bars plots data from Claypool (2007) for comparison.

Literature

Claypool, K. T. and Claypool, (2007). *On frame rate and player performance in first person shooter games.* Multimedia Systems, 13, 3–17

Ellis, S.R. & Liston, T.B. (2011), *Static and motion-based visual features used by airport tower controllers.* NASA TM-2011-216427, Ames Res. Center, Moffett Field, CA.

Ellis, S.R., Fürstenau, N., Mittendorf, M. (2011). *Frame Rate Effects on Visual Discrimination of Landing Aircraft Deceleration: Implications for Virtual Tower Design and Speed Perception.* In: Proc. Conf. HFES 2011, Las Vegas, in print

Fuerstenau, N. & Schulz-Rueckert, D. (2010). *Virtual Tower*. Special Session at: 11th IFAC Symposium: *Analysis, Design, and Evaluation of Human-Machine-Systems, Valenciennes*. Abstracts available at: http://www.univ-valenciennes.fr/ congres/IFACHMS2010/. t.b. published at: http://www.ifac-papersonline.net/