Increasing the Perceived Camera Velocity in 3D Racing Games by Changing Camera Attributes

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Abstract. This study investigates how geometric field of view, motion blur and camera altitude can be utilized in 3D third-person racing games in order to increase the perceived velocity. Related studies have concluded that geometric field of view can be used to increase the perceived velocity and, based on subjective measurements, that motion blur has no effect on the perceived speed. This research objectively measures these effects along with the effect of different camera altitudes. The results show that increasing the geometric field of view significantly increases the perceived velocity. They also show that a strong setting of motion blur decreases the perceived velocity. Moreover, the results show that higher altitudes at high velocities increase the perceived speed.

Keywords: Perceived velocity · Geometric field of view · Game camera · Motion blur

1 Introduction

Nowadays, 3D games can have a multitude of camera effects incorporated in their design. Camera shake, field of view, lens flare, occlusion, bloom, as well as variations of blur and other types of distortion are all tools at the disposal and used by game developers today. Furthermore, in games that use a third-person view the developers can also physically move the camera to manipulate the player in various ways, as explained by Schramm [4]. Schramm further argues that these effects can be used both for the cinematographic effect that they carry, but also to strengthen the perceived motion. The latter effect can be used to create seemingly fast-paced games without having to increase the actual velocity, which would usually increase the difficulty.

Elements of motion blur and changes to the geometric field of view are both often seen in games that depend or draw on a notion of high speed gameplay or interaction. We investigated what effect these methods have in a third-person view. Additionally, in games that use a third-person view, the camera is remotely attached to the object that the player is controlling; thus, we also investigated whether altering the position of the camera has an effect on the perceived speed.

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We measure perceived speed by asking test participants to match a target velocity, which is shown with one setting of field of view, no motion blur and one setting of camera altitude by accelerating a sphere to this shown velocity while seeing the sphere with another setting of either field of view, motion blur or camera altitude.

2 Related Work

Mourant et al. [3] performed a study on users' estimation of speed in a real-world driving simulator, at three different geometric field of views (GFoV): 25, 55 and 85. Geometric field of view is the concept of moving the camera back or forth in accordance with the angle of field of view, so that the viewport stays the same at a certain distance [2]. Their study found that people overestimated the produced speeds, and that increased GFoV improved their perception. The study was based on the drivers' ability to estimate a defined speed, without having a shown target speed to refer to. Thus, the results were affected by the long-term memory of the participants.

Sharan et al. [5] studied players' experience of a racing game with simulated motion blur. Their study found that there was no significant difference in the players' experience of speed.

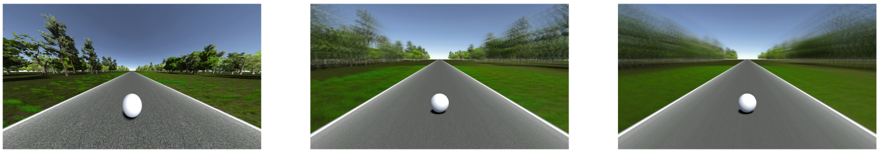
Banton et al.'s [1] experiment placed participants on a motorized treadmill set to a random speed and equipped them with a head-mounted display (n-vision Datavisor). The participants were tasked to signal if the treadmill had to go faster or slower to match the speed shown in the head-mounted display. The treadmill would then be increased or decreased in an increment of 0.5 mph. This study showed that participants set the speed too high when gazing forward. However, when gazing to the left or down, the speed was matched correctly.

In the previous studies, the research focus was not based on objective measurement of game-related speed perception. Mourant et al.'s study is based on a simulation of reality in first-person perspective, and while this study did find significant results, it is unclear whether the results also apply to video games that use a third-person view. Sharan et al.'s study found that motion blur had no significant effect on the perception of speed in a video game; however, this was measured subjectively. In our study perceived speed is measured objectively in a game environment that uses a third-person view in order to draw reliable conclusions for this kind of games.

3 Method

To measure the effect of different settings of GFoV, motion blur, and camera altitudes, a game simulation that uses a third-person camera has been created. The participants were shown a target speed with one camera setting. They were then asked to match this target speed using a different camera setting.

(a) Control setting (b) GFoV: 30 (c) GFoV: 90



(d) GFoV: 120 (e) Blur: Medium (f) Blur: High

(g) Altitude: 0 (h) Altitude: 35 (i) Altitude: 60

Fig. 1. All tested settings

3.1 Participants

Two tests were conducted with 20 participants for each test. The combined number of participants was 40, with 33 males and 7 females, of an average age of 21.2 years (SD: 2.21), the oldest being 31 years and the youngest 18 years.

3.2 Test Platform

The simulation was designed in Unity3D. The experiment was a simulation of a rolling sphere (see Fig. 1(a)). The participants were only able to change the forward velocity of the sphere (and camera). For this purpose, they were given a gamepad with analog buttons, making the changing of velocity easier. The sphere had no texture, but the environment had generated trees and grass for the purpose of optic flow, to aid the participant's perception of velocity. The environment was a straight road with a texture of asphalt, a terrain with grass close to the road, and trees further away. Every time the camera settings were changed by a facilitator (using a keyboard), the whole scene would be reloaded and the sphere was placed at a random position along the road. The simulation logged the participants' set velocity for every camera setting into a text-file. When testing, the simulation ran on a desktop PC, with a 22" full-HD screen and an Intel core i5 processor at 3.3 GHz. It was important to have a powerful desktop PC to perform the simulation without any frame-drop, because a low framerate could bias the participants' perception of velocity.

Table 1. Overview of variables for each setting.

Settings	GFoV	Motion blur	Altitude
Control	60	None	20
GFoV 30	30	None	20
GFoV 90	90	None	20
GFoV 120	120	None	20
MedBlur	60	Medium	20
HighBlur	60	High	20
Alt 0	60	None	0
Alt 35	60	None	35
Alt 60	60	None	60

3.3 Settings

The test showed each participant a target velocity followed by a setting of either GFoV, camera altitude or motion blur in which they were asked to match the shown target velocity. Each setting was used with a medium target velocity (30 m/s) and a higher target velocity (70 m/s). Table 1 shows all settings with their respective variables, as they were used in the test.

Control. The participants were always shown the target velocity, which they were supposed to match, using the control camera setting seen in Table 1 and shown in Fig. 1(a). These settings were chosen because they allowed for both decrements and increments to the settings. There was no motion blur on the control setting since motion blur can only be implemented as an incremental factor and it was not desired to have motion blur apparent in the settings for GFoV and altitude.

GFoV. Initially, only 30 and 90° were tested, which are shown in Fig. 1(b) and (c). For the second test it was decided to include a third setting at 120°, shown in Fig. 1(d). At lower or higher settings of GFoV the visual representation of the game simulation became too distorted. For these settings the distance between the controlled sphere and the camera was changed such that the sphere did not change in size.

Motion Blur. Figure 1(e) shows the implemented motion blur while Fig. 1(f) shows more extreme motion blur. Initially, only the extreme setting of motion blur was tested. While this did appear to have an effect, it seemed like it made the participants perceive the velocity as slower, contrary to what might be expected. This also stood in contrast to the results found by Sharan et al. [5] who observed no significant difference in the perceived speed when motion blur was applied.

Therefore, it was decided to implement a weaker variation of motion blur in the second test. For the test, the motion blur asset of Unity [6] was employed.

Altitude. Altitude measured in degrees describes the camera's altitude from the ground moving upwards around the controlled sphere, maintaining the same distance to the sphere. Figures 1(g), (h) and (i), shows altitudes of 0, 35, and 60°. The camera moves upwards, remaining completely behind the controlled sphere. The settings were tested in a simulation of a race-like game, thus it was decided not to test other camera-positions, e.g. side-ways views. Initially, only 0 and 60° were tested, however these settings left a wide gap between the target setting of 20° and 60°. As 60° appeared to have an effect, it was decided to test an additional setting of 35°.

3.4 Design and Procedure

The first test including the following settings: Control, GFoVs: 30 and 90, altitudes: 0 and 60 and extreme motion blur. The second test included: Control, GFoV: 120, altitude: 35 and both settings of motion blur. Both tests had participants match target velocities of 30 m/s and 70 m/s. The sequence of camera settings in which each participant was asked to match a velocity to the target velocity in the control settings, as well as the sequence of target velocities was always randomized.

The participants were shortly briefed about the test before starting the test. The short explanation described the task, the controls of the gamepad, the general procedure and minor details. The task was to match a target velocity which would either be 30 m/s or 70 m/s, and they could swap between the camera settings in which their chosen velocity was shown and the control setting in which the target velocity was shown. This swapping was performed twice for each tested camera setting. The short swap was controlled by the facilitator when signaled by the test participant. The participants were told that the acceleration which was controlled by the gamepad changed randomly throughout the whole test. Before each new camera setting they were asked to get a good feeling for the target velocity that they had to match first before changing to the camera setting in which they controlled the velocity. The process of swapping back and forth between the target speed and their estimation was implemented to ensure that the participants were able to reach the speed they perceptually felt was accurate, and not the speed they felt was correct based on memory.

After the task was finished, the participants were asked the following questions: age, possession of driver's license, experience in driving the last year, experience in video games and experience in racing games.

4 Results and Discussion

All graphs show the participant's estimated speeds, when matching a target velocity of either 30 m/s or 70 m/s, with the control setting, as described in Sect. 3.3.

Thus, the estimated speeds for 60° GFoV, no motion blur and 20° altitude used the same camera settings (the control settings) when showing the target velocity and when the participants chose a matching velocity. In this case, the estimated velocities are not significantly different from the target velocities, and they have the lowest standard deviation amongst all the collected data, indicating that the task of matching a presented velocity was possible for the participants.

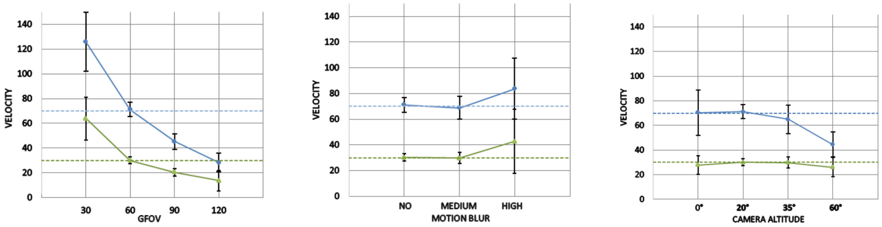
The data has been analysed for variance, using a t-test with a confidence alpha level of 0.05. Due to the previous studies explained in Sect. 2 it will be assumed that GFoV will significantly increase the perceived velocity, leading to a one-tailed analysis while motion blur and altitude will be analysed as two-tailed, since no assumptions can be made. The t-test will analyse for variance from the target velocities of either 30 m/s or 70 m/s.

4.1 Results for GFoV

As suggested by the results of Mourant et al. [3] and Diels et al. [2], it was expected that changing the GFoV would also have an impact for the third-person view. The graph in Fig. 2(a) shows that participants would have a much higher estimated speed than the target with a GFoV of 30°. Thus the speed appeared slower. The results also show a high variance, indicating that the participants had a hard time estimating the speed with this camera setting.

For a GFoV setting of 90°, the estimated speeds drop below the target velocity. The variance also becomes smaller, when compared to the setting of 30°, showing that the participants had a higher degree of agreement regarding the estimated speed. The mean estimation when matching the velocity of 70 m/s was 35.1% lower, and 32% lower when matching the velocity of 30 m/s. A one-tailed t-test shows that the participants perceived a setting of 90 GFoV to be significantly faster than the control setting with 60 GFoV.

The results for the GFoV setting of 120° show that as the GFoV increases further, the effect also increases. The estimated mean values for the target velocity of 30 m/s is 54% lower and 59.9% for the target velocity of 70 m/s. They are also 32.4% and 38.1% lower, compared to the mean values of GFoV 90, indicating that the strength of the effect does not appear to diminish as the setting increases.



(a) Results: GFoV (b) Results: Blur (c) Results: Altitude

Fig. 2. Graphs of results

4.2 Results for Motion Blur

The results found by Sharan et al. [5] suggest that there was no significant effect of motion blur on the experience of speed. The graph in Fig. 2(b) shows that there is no significant difference between no motion blur and a medium setting of motion blur. However with a strong setting of motion blur, a two-tailed t-test shows that the estimated mean values are significantly higher than the target velocities showing that the participants perceived the speed as slower. When matching a target velocity of 70 m/s, the mean values of the estimated speeds are 19.6% higher and with a target velocity of 30 m/s they are 42.3% higher. This, along with the strongly increased variance in the estimated values shows that the participants had a difficult time perceiving the speeds, which many of the participants also stated during the test. The estimated values for the target velocity of 30 m/s was relatively higher than the estimated values for the target velocity of 70 m/s. This may indicate that in order to recognize movement when a strong setting of motion blur is applied the velocity needs to be higher than a certain limit.

4.3 Results for Altitude

The graph in Fig. 2(c) shows that the mean estimated velocities for 0° altitude are not significantly different from the target, but the variances are high, which indicates that the participants had difficulties estimating the correct velocity. The altitude of 35° did not have a significant difference when matching the target velocity. Relative to the average, participants set it 7.2% lower. For the altitude of 60° both target velocities are significantly different according to the two-tailed t-test. When matching the velocity of 30 m/s, the participants matched it 13.3% lower, and for the velocity of 70 m/s they matched it 36.4% lower. Thus indicating that the velocity at an the altitude setting of 60° was perceived significantly faster than the target velocity with an altitude of 20°. In Banton et al.'s [1] research, the perceived velocity for forward-gazing was slower than for downward-gazing which allowed for a more accurate perceived velocity of the simulation. In our test, the altitude of 60° corresponds to a downward gaze which agrees with the trend in Banton et al.'s research. When the altitude is set to 60°, the only optic flow is due to grass and the road while slow moving objects near the horizon are not visible. At a high velocity, the grass might move so fast that matching the target velocity becomes particularly difficult.

5 Conclusion

For the GFoV of 90 and 120° it can be concluded that the perceived velocity was significantly increased. Further, for a GFoV of 30° it can be concluded that the perceived velocity was significantly decreased. Thus, it can be concluded that increasing the GFoV can significantly increase the perceived velocity in a game with a third-person view. It cannot be concluded whether the effect will be lost as the GFoV increases beyond 120, and the data did not show any signs of the effect diminishing as the GFoV was increased to this point.

For the medium setting of motion blur, the perceived velocity was not significantly increased. For the high setting the perceived velocity was significantly decreased. Thus, it can be concluded that motion blur does not significantly increase the perceived velocity in a 3D third-person game.

For the camera altitude, the setting of 60° can be concluded to significantly increase the perceived velocity. The data also shows that a setting of 35° altitude at the high target velocity had a tendency towards increased perceived velocity, however it had no significant effect at the lower target velocity. This suggests that the effect of a higher camera position may be more effective at higher velocities.

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