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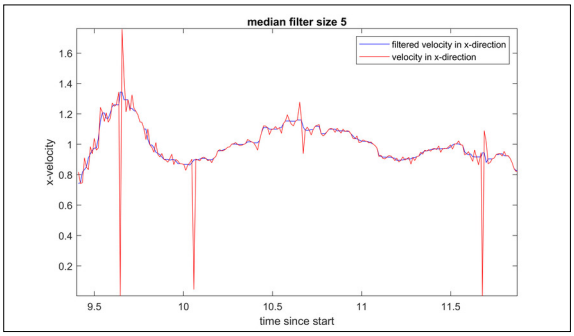
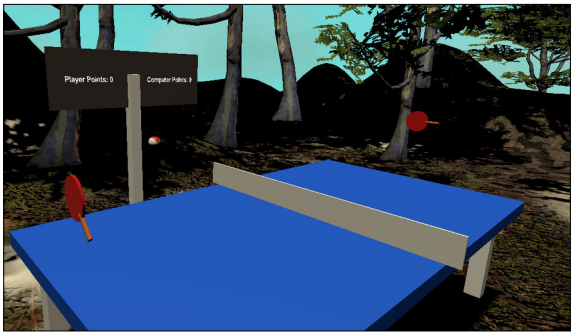
Subject Area	Control Theory

Development of a Unity-Based Table Tennis Game with a Virtual Opponent

HTC Vive Pro full kit
Digitec Website



Comparison unfiltered velocity and median filtered velocity
Own presentment



Screenshot of the final version of the table tennis game
Own presentment

Definition of Task: Virtual Reality (VR) is one of the major trends in the entertainment industry. While lots of different industrial sectors advertise with potential fields of application for the VR, they are currently mainly used in the gaming industry.
In this thesis, a virtual game for the VR headset HTC Vive Pro will be developed. The aim is to play table tennis against a virtual opponent. Unity was chosen as the development environment which uses Visual Studio to code the scripts in C#. The virtual opponent should have access to the coordinates and velocities of the ball and therefore be able to move according to the physical limits of a real player.

Approach: The development of the table tennis game is grouped into 5 main parts:

- Basic game design: The first task of the project is to set-up a basic environment. This includes the design of the table, rackets and a player interaction system. This first version of the game made it possible to grab a ball and throw it away.
- Collision management: The second part was the interaction between the racket and the ball. To achieve a realistic behavior of the ball, it was necessary to detect the collision and calculate the corresponding trajectory of the ball. In order to access the controller movement speeds, the velocity of the racket is approximated using derivatives of the positions and filtering the signal with a median filter.
- Implementation table tennis rules: The third part was the development of a state machine to control the game process. The state machine detects when a fault happens, chooses which player serves and counts the points. The different states change based on the collisions between the ball and the different objects in the game.
- Implementation spin: The basic collision calculation was adjusted, such that ball can get spin. The spin influences the direction of the ball after the collision. In addition, the magnus effect is included here. The Magnus effect generates a force which affects the trajectory of the ball depending on its spin and velocity.
- AI opponent: The last part was the implementation of an artificial opponent called AI. The AI gets the precalculated trajectory of the ball and chooses the nearest point play the ball back. The movement of the AI is controlled over a limited acceleration which makes the movement behave in a realistic manner.

Result: In the final version of the game it possible to play table tennis against an AI. The spin of the ball affects its collisions and trajectory similar to a real table tennis game. The movement of the AI racket is controlled over limited accelerations to make the movement realistic. The difficulty level of the opponent can be adjusted by changing the maximal accelerations. The points are displayed in the game and a small forest is built around the scene to make the environment more enjoyable.