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M. Kur

Overcome jitter behaviour of objects on small scale in physics simulation

Abstract. The method of extrapolating physic simulated position data and improving collision detection via continuous dynamic are suggested, thus improves the overall accuracy of object movement on small scale.

Keywords. Physics simulation, accuracy, collision detection, interpolation, self-driving robotic car.

Introduction. In the modern world, there is high demand in accurate and fast physic simulations, that can be used in fields such as training AI to drive vehicles, indoors and outdoors robots, etc. Many mainstream physic engines are developed with a normal-to-big object scale in mind (from 1m table to 100m building) [1]. But, on small scale (down to millimeters), absolute solid body (ASB) spins unpredictably or jitters back-and-forth on other flat ASB or object A goes through object B when objects move too fast to detect their intersection.

The research aims to improve the accuracy of physic simulation of the object's movement on small scale, for realistic physics in a machine learning environment, using various interpolation methods and changes to the collision detection system.

Research results. The research is provided for the development of a simulator for self-driving cars AI training using machine learning, featuring car modeling. The changes to the physics engine aim to improve the accuracy of cars position and hit detection with other objects, to provide more accurate data for training.

The root cause of jitter behavior of ABS, such as unpredictably tiny changes to object rotation or object go through other objects at high velocities (a problem is also known as tunnelling) – lack of accurate collision detection, thus some parts of an object falls into another object, gots corrected which changes original object position and rotation.

As the first step, the physics calculation time interval was changed, from 0.01s to 0.002s. This change allowed the physics engine to process the physic frame more frequently (about 80%), thus detecting and correcting possible issues quicker with a lower delta in changes for position or rotation[2]. As a downside, this change requires more computing power to process the same scene with a given time-frame, due to higher raw calculation of the physics engine.

The next step aims at the overall improvement of the collision detection system by changing the detection method and further tuning of it. The discrete collision detection system was changed in favor of the continuous collision detection (CCD) system. That system activates between ABS whose relative speeds are above the sum of their respective velocity thresholds. These velocity thresholds are automatically calculated based on the object's shape properties. Also, CCD's system was tuned for a smaller advance coefficient from 0.15 to 0.10, to eliminate the likelihood of objects clipping into another object at the end of the physics frame within the last collision detection pass [3].

Another type of CCD system was considered, namely Raycast CCD, which is based on performing raycasts from the object's center positions to verify that the tunnel didn't occur. The advantage is that the raycast system is less expensive to execute compared to CCD. But it's very approximate for two dynamic ABS. As a result of testing this system, it was stated that Raycast CCD isn't perfect for such use-case, because ray, that trace from the center of an object, can go through other objects if those objects have holes or imperfection between their parts.

Conclusion. During the research, it was concluded that proposed changes to physics engine simulation, which include change of collision detection system and increasing physics calculation time interval, resulted in more accurate behavior of small objects and their collision detection at high speed. Specifically, changes in the physics calculation time interval, from 0.01s to 0.002s, resulted in the lowered delta of unpredictable tiny changes to object rotation and position, from initial ±0.0087 to ±0.000493 units, achieved delta changes converts to unpredictable changes under 0.5 millimeters.

References

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