Real vs. approximate collisions: when can we tell the difference

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Real vs. Approximate Collisions: When Can We Tell the Difference?

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The behaviour of objects in the physical world is described by Newtonian mechanics, using dynamic concepts such as force and mass. However, it has been reported that many people have intuitive preconceptions concerning mechanical events that, although incorrect according to Newtonian mechanics, are highly stable and widespread.[3] Profitt and Gilden showed that people use only one dimension of information when making dynamical judgements.[6] Therefore, when a dynamic event involves more than one dimension of information such as velocity and rotation (i.e. an extended body motion as opposed to a particle which has only one dimension of information), humans are less able to correctly identify anomalous physical behaviour. They also discovered that judgements about collisions were made based on heuristics and that people are influenced by kinematic data, such as velocity after impact and the way that the colliding objects ricochet.[4]

Can we exploit this imprecision of the human brain for the purpose of producing plausible real-time simulations of colliding objects? Earlier work has exploited the plausibility of certain types of approximations for simulation.[1,2] In particular, if less time is spent on processing a collision, under what circumstances will this degradation in accuracy be imperceptible? In this sketch we will present several robust factors that can significantly affect a viewer's perception of a collision and may be used to prioritise collision processing in a perceptually-adaptive system. The effect of these factors was examined in a series of psychophysical experiments.

Causality refers to the ability to detect whether one event causes another.[5] For example, a collision of a moving object with a stationary one will cause the second object to move, whereas a stationary object that starts to move by itself is perceived to be autonomous. We ran an experiment similar to Michotte's famous causality tests and found that adding a time delay between object contact and collision response reduced the perception of causality and thereby the plausibility of the collision event itself. Therefore, we can conclude that constant frame rates are imperative in any real-time collision handling system and hence interruptible collision detection is the only feasible solution for large numbers of complex objects.

Interrupting collision detection before it is complete either leads to interpenetrations, which are usually unacceptable, or more frequently to objects which bounce off each other at a distance. We found that the separation of objects when they collide provides a strong visual impression of an erroneous collision, but that this effect may be ameliorated by factors such as occlusion of the collision points, eccentricity (i.e. peripheral events) and the presence, number, and type of distractors (e.g. visually similar distractors have a stronger masking effect).

We also found that, despite reduced collision detection resolution, it is possible to produce a random collision response that is as believable as the more accurate ones, thus further masking collision anomalies. As Profitt and Gilden found, we conclude that people seem to be capable of correctly perceiving errors in collision response only when there is one salient feature (such as gap size), whereas when the simulation becomes more complex, they rely on their own naïve or common-sense judgements of dynamics, which are more often than not inaccurate. We are now conducting further experiments, using an eyetracker as shown in Figure 1, to identify the effect of these factors in more complex scenarios with large numbers of colliding entities. We will discuss the results of these experiments also.

References
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Figure 1. New Experiments using an eye-tracker.