Scunnerball: An analysis of the motion characterstics of spheroids with high coefficient of restitution in tabletop interaction.

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Abstract—The bizarre physical properties of rubber balls with extreme coefficients of resitution are well known. In this paper, we propose a novel interaction techinque based around the unpredictable rebounds of the balls. A situated game "Scunnerball" is developed via a user-centered design process. We show a number of studies identifying optimal layouts for Scunnerball games, and demonstrate empirically that the game is optimal with a number of players such that N (the number of players) is given by $N \equiv 0$ mod 2.

I. INTRODUCTION

scunner, v. 1. intr. To feel reluctance (to do something); to hesitate; to feel disgust, revulsion or discouragement.
–The Dictionary of the Scots Langauge

Ultraelastic rubber spheres have long been known to exhibit unpredictable behvaiour. Figure 1 and 2 show examples. These physical properties are described in detail in [1]. A modern comparison of the bouncing behaviour of various ball types is given in [3].
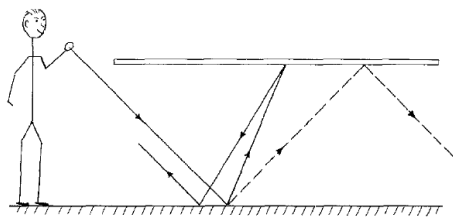

Figure 1.   A Scunnerball undergoing multiple rebounds. Note the non-repeatable nature of the interaction. Courtesy of [1].
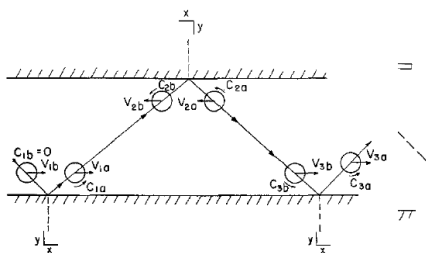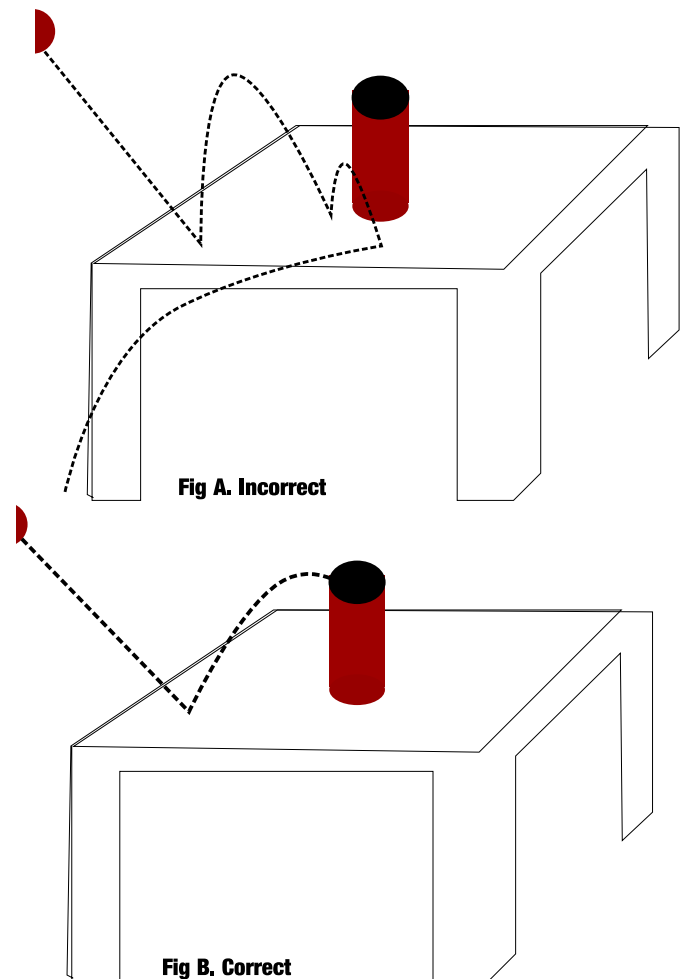

Figure 2.   Multiple rebounds view from above. From [1].

We propose a game based upon multiple rebounds of such objects against a rigid surface, terminating in the ball being captured within a cylindrical container. The figures below illustrate. Players aim to induce the balls to enter the central container within a single rebound.

Fig A. Incorrect

Fig B. Correct

We postulate that the semi-stochastic nature of this game functions as a socially binding experience, while maintaining a sufficient progression of skill to keep long term interest. Our investigations have shown that there is significant net hedonic value in this form of interaction.

II. Scunnerball Simulation

Some typical synthetic Scunnerball trajectories are shown in Figure 3. The chaotic nature of the rebounds is key to the success of Scunnerball as a game. We modelled each Scunnerball as a massive collection of randomly connected springs, inspired by the form of a cat's hairball. By randomly sampling points on the unit sphere, and connecting each point to some random number of its nearest neighbours, a rigid spherical structure with curious deformation properties is created. This model was refined by introducing multiple coencentric spheres, each layer connected to the previous via yet more springs, to simulate interactions inside of the body. Figure 4 illustrates.
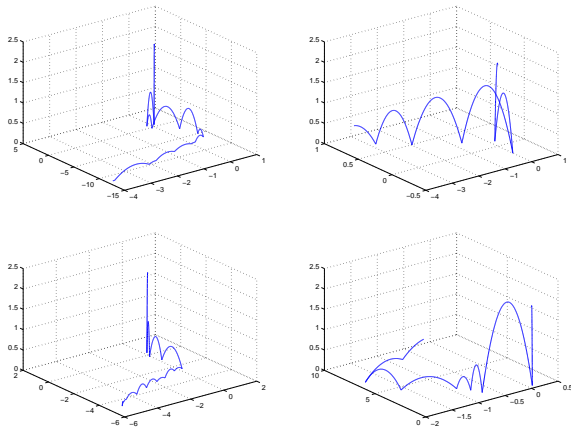

Figure 3. Synthetic Scunnerball trajectories. A highly realistic computer simulation of Scunnerball shows how the little buggers bounce like they have a mind of their own.
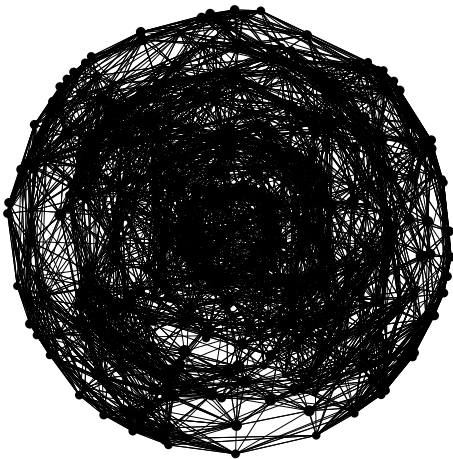

Figure 4. A detailed mathematical model of a Scunnerball. A sparse spring-mass-damper system with stochastically arranged surface points is used to simulate the ball surface. Multiple tiers are used to simulate volumetric effects.

III. Technical aspects

The game is played with a 18mm vulcanized polybutadiene ball. Such balls have a coefficient of restitution of approximately 0.876. The players assemble around a wooden table approximately 1m in diameter. Either round or square tables are suitable. A cardboard tube, 170mm high and with a 60mm opening is placed at the geometric center of the table. Figure 5 illustrates. Each player throws the ball (underarm or overarm) onto the table. The ball must enter the tube after rebounding at least once in order for a point to be scored.
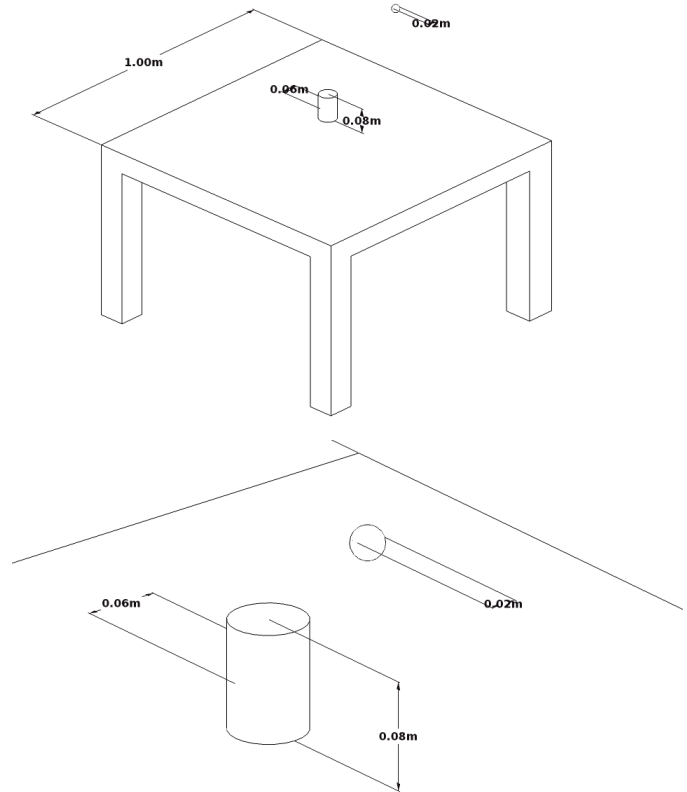

Figure 5. The layout of a Scunnerball game.

One anomaly noticed during testing is the high ratio of rim-rebounds ("rimshots") to tube entries. This is due to the generally low angle of entry of the scunnerballs. Figure 6 illustrates various trajectories. Higher angles are clearly superior. In fact, only a very small area of the tube entry can be entered by the ball, as Figure 7 illustrates.

IV. Development

A. Study I

Initial versions of the game featured just the tube on the table. Despite the obvious potential for an involving interaction, evaluations suggested poor in-the-wild perfomance. An ethnographic study was carried out to examine how people used this early version of Scunnerball in their everyday lives. This revealed that the game played no part in people's everyday lives. An extract from one of the interviews conducted illustrates the problem:

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NA (interviewer): So, uhh, you're
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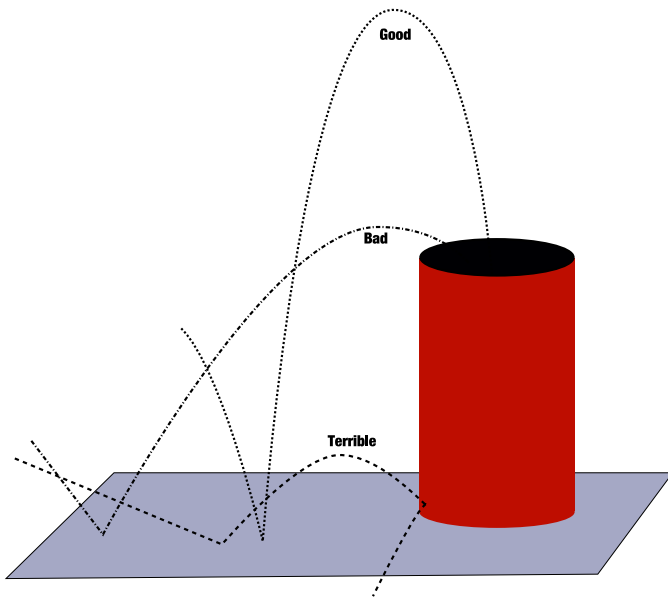
Figure 6. Different angles of entry. Higher angles have a much higher chance of success.
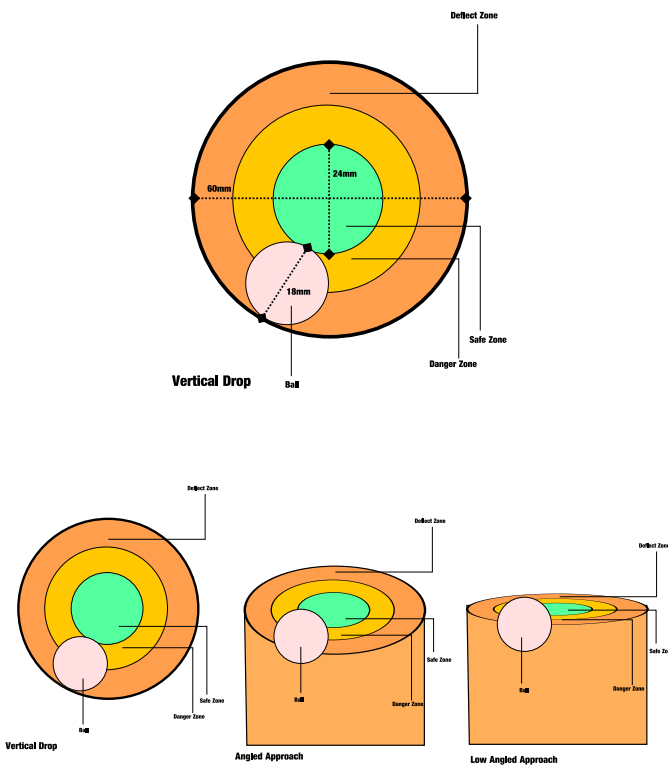

Figure 7. Diameter of the ball compared to the diameter of a tube. Even with a perfect vertical angle, there is still a small margin of error for successful entry. As the angle of entry increases, this margin drops rapidly.

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     playing Scunnerball...
VN: uhh, what?
NA: on the table, there, the tube...
VN: the toilet roll?
NA: no, no, it's part of a system we're
VN: a system?
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NA: uhh, yeah...
VN: but it's a toilet roll on a table...
NA: how do you think it's, umm,
    affecting your life? Do you feel it
    opens up possibilities?
VN: no, man, umm, are you sure...
NA: yes. It's a system. We built it.
VN: uhh ok. Well my life.
    It's unchanged. I mean I just, you
    know, walked by this table and you
    started talking to me.
NA: But you saw the tube?
VN: well, no, not until, you know, you...
NA: What would you say the most
        appealling thing about
        Scunnerball is?
VN: what?
NA: Scunnerball
VN: what's that?
NA: Our system!
VN: The tube?
NA: YES!
VN: uhh ok, man, why
        is it called that? it's just...
        just a bit of cardboard.
NA: Well, uhh, ok. Thanks for
        your time.
VN: Yeah, sure, OK.
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B. Study II

Although the design team was discouraged after these intial tests, development was continued in the hope that some useful outcome could be salvaged. After several rounds of paper prototyping, and a two day workshop, the rubber ball was introduced. This major innovation dramatically improved users' subjective ratings of the game. Despite the fact that the initial rules, which required that the ball simply to be dropped into the tube, proved somewhat underwhelming, the Scunnerball system was already nearing completion.

In order to rework the rules to better suit the target audience, a design theatre event was held. A two player game of Scunnerball was performed, set to the music of Tchaikovsky. Two actors perfomed the part of the players, one played the tube, and the remaing actor playing the ball. This event, however, was unsuccesful, largely due to the severe injury of the actor playing the tube in the second act, leading to the termination of the meeting.

The final rules were in fact discovered accidently after a ball escaped during an un-calibrated test sequence. The excitement of the unpredictable motion led to something of a commotion among the designers present. Thus, we integrated the rebound component as core functionality in the Scunnerball game.

As before, we integrated the system into an everyday context, and then asked people to interact with it. A semi-structured interview was carried out to examine people's reactions to Scunnerball.

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NA (interviewer): Hi again.
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VN: yeah... <bouncing>
NA: so I've a few questions...
VN: aww yeah! <bouncing>
NA: so, Scunnerball are you...
VN: IN THE BAG! you jammy...
NA: enjoying it?
VN: what? ****'n rebound again!
NA: Could you just pay...
VN: <bouncing> COME ONN!
NA: Do you think...
VN: Hey, could you, uh, YES!,
    could you keep it down, I'm
    trying to play here
NA: But could you just tell...
VN: **** off! Oh yeah! Rim shot! <bouncing>
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V. NUMBER OF PLAYERS

One of the key design decisions in the creation of Scunnerball was the number of players required. During the iterative refinement of the game, it was determined that there must be a number of players such that each player is paired with exactly one other, i.e there must be an even number of players. Figure 8 illustrates the problem with player layouts where the player set cannot be partitioned into two sets of equal cardinality.
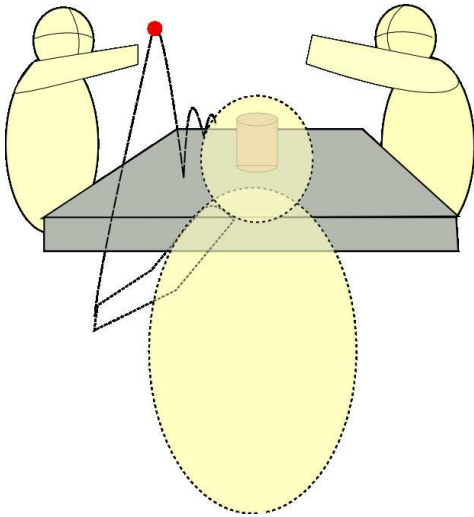

Figure 8. An odd number of people play Scunnerball. Catching fails.

VI. CONCLUSIONS

We have presented a novel desktop interaction metaphor, based on the stochastic nature of rebounds with highly elastic objects. The system described is only one small point in a whole new vista of bouncy-ball related games. Developments such as multiple colors of balls, different sizes of tubes (for a system of handicaps) and even multiple simultaneous balls could be used to enhance the interaction. Our previous work on bouncing ball interaction [2] suggests that there may even be mobile applications for the Scunnerball metaphor.

REFERENCES

[1] R. L. Garwin *Kinematics of an Ultraelastic Rough ball*, **Am. Jour. Phys.** 37:1 pp 88–92 1969
[2] J. Williamson, R. Murray-Smith, S. Hughes *Shoogle: Multimodal Excitatory Interaction on Mobile Devices*, **ACM SIG CHI** 2007
[3] R. Cross *The Bounce of A Ball*, **Am. Jour. Phys.** 67:3 pp 222–227 1999

APPENDIX

The official rules of International Scunnerball are appeneded below.

1) Aim
   Players aim to bounce balls so that they come to rest inside inside a cardboard tube placed at the centre of a wooden table. Players alternate throwing the balls, until the balls are exhausted. The player with the most points wins.

2) Bounce rules
   A point is scored if the ball enters the tube and settles there. If it bounces back out, no point is scored. The ball must bounce a minimum of once before entering the tube. A ball which enters without a bounce must be retrieved and reused. Additional bounces count for additional points – e.g. two bounces gives two points. The bounces must either be upon the play surface, or from the rim of the tube. Each bounce must be at least one ball height, so that there is no confusion when balls make small, rapid bounces.

3) Size Regulations
   Each ball must 18mm in diameter. The tube must have a 60mm opening, and a height of 180mm. The table must be a minimum of 1m wide. The tube shall be placed at the centre of the table. In the event the tube falls over, the umpire shall replace it at the centre before play resumes.

4) Participants
   Each game is conducted between two players. An umpire must be present at all times. The starting player is decided by coin toss.

5) Throws
   Any throw style may be used, so long as it does not endanger the players or the balls. If a player suspects the throw is dangerous, they may exclaim "Crossan, put that down." No part of a player's hands may extend beyond the edge so they are over the table. The umpire should call foul if this is observed. Once a player has released the ball, he may not touch it until his opponent catches it. Touching the ball after the release will invalidate the throw. The opponent may not catch or otherwise interfere with the ball until it is clear that the ball cannot enter the tube.

6) Ball choice
   At the beginning of a set, players take turns to select balls. If the game involves an odd number of balls, the player winning the coin toss chooses one extra ball. Balls will naturally move from player to player during the course of play. If a ball settles on the same side of the tube as the thrower the player may retain that ball. If a player has no balls, his opponent must pass him one to allow him to play. The opponent may choose any ball to pass. When all balls have re-entered the tube, the tube is again emptied and players re-select.

7) Positions
   Players stand opposite each other. Players alternate positions after each round.

8) Game structure

   a) Sets
      Each match consists of a number of sets. Each set consists of a number of rounds. A round is considered complete when a point has been scored. Players alternate throws in each round, except that when a point is scored, the scoring player plays again. If all rounds in a set are won by one player, the other player is "totally scunnered".
   b) Matches
      The player winning the majority of the sets wins the match. If it is still tied, a sudden death game is played. The first player to tube the ball wins.
   c) Quarter Finals
      Each set consists of five rounds. There are three sets for each match.
   d) Semi Finals
      Each set consists of seven rounds. There are three sets for each match.
   e) Finals
      Each set consists of seven rounds. There are five sets for each match.