Dynamic Friction Polymer

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Abstract
In this paper the authors describe a fictitious material that addresses many restriction that currently exists in our world. Based on the theory of Radical Atoms[1]. This new material is a Dynamic Friction Polymer. DFP inherits parameters and rules from Finite Elements Software allowing it to change its properties and optimize its behavior accordingly. Thus, DFP undertakes a new paradigm where friction and matter are in a constant change in a symbiotic, two-way relationship.

Author Keywords
Friction, Shape shifting, Radical Atoms

ACM Classification Keywords
H.5.2. Information interfaces and presentation: Prototyping

General Terms
Performance, Design

Introduction
Friction is resistance for objects in motion, and is a material property for every object in our world. We propose a new material that is capable of changing it's coefficient of friction as needed to achieve a specific goal; a Dynamic Friction Polymer. DFP inherits parameters and rules from Finite Elements Software allowing it to change its properties and optimize it's behavior accordingly.

Vision
We envision DFP having a use in hardware at home, the tire manufacturing industry, or even the flooring industry. We envision DFP functioning by measuring the

weight of the object and it's position on the material. If DFP finds an increase in weight, it increases the friction; if it finds movement in the object, it decreases the friction while taking into consideration the speed of the movement and the original weight of the object – the faster the movement is, and the heavier the object is, the more friction is reduced.

Related work

Our work is informed by prior work done inspired by the Radical Atoms.

deFORM

deFORM is a deformable input device that supports 2.5D touch gestures, tangible tools, and arbitrary objects through real-time structured light scanning of a malleable surface of interaction. deFORM captures high-resolution surface deformations and 2D grey-scale textures of a gel surface through a three-phase structured light 3D scanner. This technique can be combined with IR projection to allow for invisible capture, providing the opportunity for co-located visual feedback on the deformable surface

Claytronics

Claytronics is an abstract future concept that combines nanoscale robotics and computer science to create individual nanometer-scale computers called claytronic atoms, or catoms, which can interact with each other to form tangible 3-D objects that a user can interact with. This idea is more broadly referred to as programmable matter.[2] Claytronics has the potential to greatly affect many areas of daily life, such as telecommunication, human-computer interfaces, and entertainment. [Figure 1]

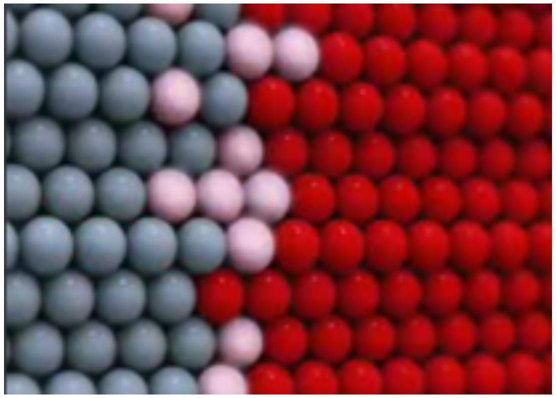

Figure 1: Claytroncs molecular shifting illustration.

Perfect Red

Perfect Red represents one such possible substance: a clay-like material preprogrammed to have many of the features of computer-aided design (CAD) soft-ware. Perfect Red is a fictional material that can be sculpted like clay—with hands and hand tools—and responds according to rules inspired by CAD operations, including snapping to primary geometries, Boolean operations, and parametric design.

Nanomachines

Nanomachine is the general term for a machine ranging in size from one micrometer (one-thousandth of a millimeter) to one nanometer (one-millionth of a millimeter) using MEMS (Micro Electro Mechanical Systems) technology[3]. An example of a nanomachine would be a protein aggregate resembling the structure of a man-made motor using biomolecules such as DNA, proteins, and resins a Text formatting

DFP Design Rationale

Our vision of DFP requires actuation and communication at the nanoscale. The material property changes at the molecular level was inspired by the work at the self-assembly lab at MIT. DFP is imagined as one of a number of new materials rich of complex set of responsive behaviors. The idea was intended to demonstrate the richness of Radical Atoms in how they can combine the opportunities that the digital world and physical prototyping with the parametric operation of computer-aided design tools.

There are several scenarios we conceive DFP is most applicable. Firstly, in the industry of automobiles. Currently, the number of car accidents happening around the world is increasing year by year. One reason is because abrasion of tires caused imbalance in the vehicle. Using thermal degree as indicators of abrasion level, the material of the car will automatically adjust the coefficient of friction of the surface when it’s too hot, thus lessening the friction of the most abraded parts accordingly. [Figure 2] Further, different tires have various features, including noisedamping, electrical insulating, land gripping, etc. we want to combine all these features in one tyre and enable it to change its surface material according to environment, weather changes. And the static electricity conserved in the tyre while traveling can be used to realize this computation. [Figure 3]

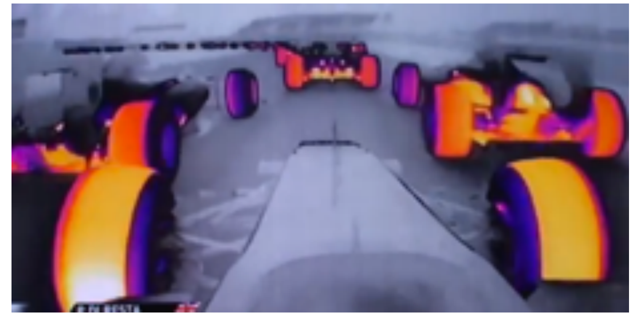

Figure 2: Thermal distribution of vehicles

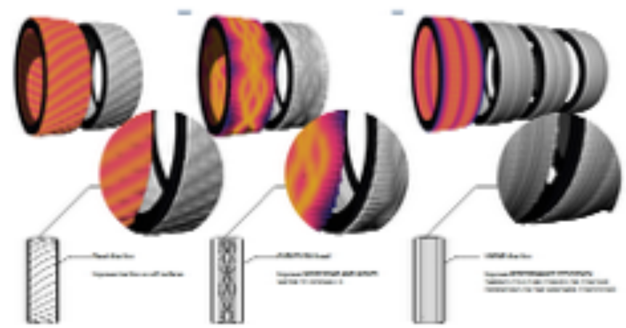

Figure 3: Various features of tires

In addition, DFP can also be applied in family hardware. There are often times when we need to move a piece of heavy furniture at home. But at the same time, when we place a piece of furniture, we wish to stabilize it. In this scenario, we wish to increase the floor’s friction when stabilizing it while reducing the friction when moving it. When the floor senses a horizontal long-lasting force, it’ll automatically adjust the coefficient of friction of the surface, enabling us to move the furniture easily. [Figure 4]

Figure 4: Floor changes friction when senses a horizontal force

When we sit on a chair, we wish it to be as stable as possible, while when we move it we wish to reduce the floor's friction. When the material finds movement in the object, it decreases the friction while taking into consideration the speed of the movement and the original weight of the object—the faster the movement is, and the heavier the object is, the more friction is reduced.

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Figure 5: Floor adjusts its friction taking into consideration the speed of the movement and the original weight of the object.

DFP Prototype

We simulated the change of friction with Silicone, which is high in friction coefficient, and Acrylic glass, which is slippery on its surface.

We constructed a series of tiles where each tile consists of Acrylic glass of three different thickness: the top cover layer is a square with side-length of 3.5 inches and thickness of 1/16 inches; the middle frame layer is two 1/4-inch frames with outer side-length of 3.2 inches and inner side-length of 2.75 inches; the bottom support layer is 1/8 inches in thickness and the same size as the top layer. We also cut a 6-by-6 matrix of circles at the center of the top layer to allow the inside air bag to inflate through. The diameter of the circles is 1/4 inches, and the interval between circles is 1/8 inches.

The casting process for our prototype was highly inspired by PneUI[4]. We made air bags with Silicone of Ecoflex® 0010 and sealed one bag inside each tile with plastic glue. We also drilled a small hole on the frame layer and penetrated a thin tube into the air bag from outside of the tile. An air pump was deployed to inflate air bags, and each air bag can be inflated individually with the control of attached valve. [Figure 6]

By controlling whether to inflate the air bags, we showed it possible to slide a book from one side of the table to another or to stop the book in halfway. We also revealed the possibility to keep a book on a slope to ease the reading behavior. With these demos, we proved the feasibility for dynamic control of friction. [Figure 7]

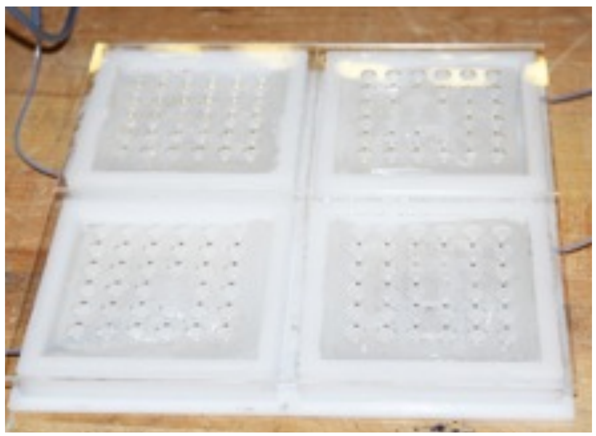

Figure 6: Prototype of DFP

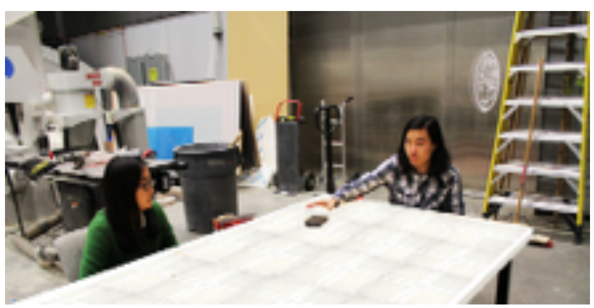

Figure 7: Demo of objects passing through DFP surface

Future Work

From the perspective of control mechanism, in this prototype, we enabled each air bag to be inflated individually. In the future, we want to control each air bubble on the surface to make the adjustment of friction more accurate and controllable. From the perspective of fabrication, we aim to fabricate more air bubbles on each air bag, and make each air bubble smaller, in order to make the change of friction more delicate.

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