Bending Burning Matches and Crumpling Burning Paper*

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Abstract

In this work, we present a freeform deformation guided by physically based processes to model bending of objects when burning. Specifically, we can simulate the bending of burning matches, and the folding of burning paper interactively.

1 Introduction

We present a simple method to increase the realism of the simulation of burning objects. The pyrolysis process, where an object releases combustible gases, causes decomposition and additional structural changes in burning objects. Although the latter effect is usually minor, it creates a dominant deformation on small objects, such as matches or paper. The main aspect of our work is that we present an FFD-based method for modeling such phenomena. We control the deformation according to the changing object properties encountered during the simulation.

2 Simulation guided FFD

[Melek and Keyser 2003] implements a simple but effective model for simulation of the decomposition of burning objects using a levelset method. [Losasso et al. 2006] models burning objects using remeshing, and can model fine scale decomposition structures. Yet none of these works address secondary deformation effects due to structural changes. Although this effect is usually minor, it creates a dominant deformation on small objects. Examples include the upward bending seen in burning matches and the crumpling of burning paper. Rather than modeling the actual chemical process, we propose a simplified model to mimic similar behavior. Similar to [Melek and Keyser 2005] we use the change of object properties during the simulation to control the deformation.

An FFD lattice is placed around the burning object and object properties are mapped onto the faces of the lattice. The difference of the mapped amounts on the opposing faces defines the deformation amount. The object bending or crumpling is then achieved by warping the local coordinate system using an FFD.

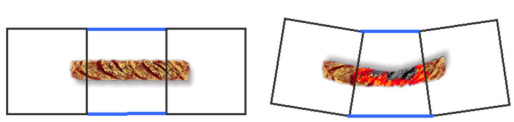

Figure 1: Curling match using simulation guided FFD

To model curling matches, we place a “1D” FFD lattice around the solid. The amount of decomposition and heat are mapped onto the faces of the lattice. The lattice faces are contracted or expanded according to the difference on facing faces.

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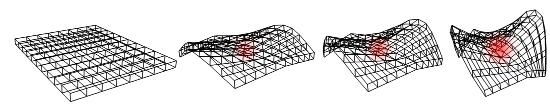

Figure 2: Deformation of the center cell on the “2D” lattice

To model crumpling paper, we use a “2D” lattice. Similar to the previous example, decomposition and heat are mapped onto the faces. The deformation of every cell is controlled similar to the previous example, but the deformation itself is modeled as a cosine function. The collection of individual deformations results in a crumpling action. Note that a cloth-like solver could also be used to on the FFD lattice to create crumpling-like action.

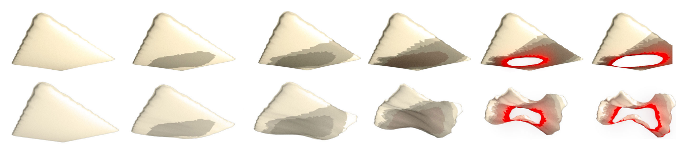

Figure 3: Crumpling paper during burning. (a) decomposition alone, (b) decomposition and crumpling. Flames are not show.

3 Implementation and Results

Using our fire simulation framework [Melek and Keyser 2002], we implemented the proposed model. The FFD model is placed between the flame simulation and solid decomposition processes. The proposed process is simple, and could also be used to model similar behavior in other small-scale objects. By using an FFD approach, we can deform complex models without the additional simulation cost associated with modeling the actual physical process of the secondary deformation.

References

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