Vegetable Matter Decay: An Exceptional Student 'Innovations' Project

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Figure 1: *Apple decay simulation.*

Abstract

We present an outstanding undergraduate research project that has resulted in the development of a parametrised method for simulating drying and decaying vegetable matter from the fruits category, taking into account the biological characteristics of the decaying fruit. This work was awarded 1st place in the undergraduate category of the ACM Student Research Competition at SIGGRAPH 2018.

1. Introduction

Capstone projects are frequently the first real research project that undergraduate students encounter, but they are not the only type of undergraduate research project. For more than two decades the National Centre for Computer Animation (NCCA) has run a final year undergraduate course referred to as the "Innovations Project" that has existed almost unchanged for this period and that is separate from the students' "Major Project" capstone course. Since its inception several assignments developed and completed in the course of the "Innovations Project" have resulted in sketches and posters presented at SIGGRAPH, including the project presented here [CA18] (Figure 1), which was awarded 1st place in the undergraduate category of the ACM Student Research Competition.

2. Project Context

In this course, students select a project according to their interests in terms of their aspirations and specialism with the aim to produce innovative and experimental work, which does not have to encompass research in the traditional sense but can be an exploration of recent developments that are not yet included in their curriculum.

This course is delivered to two Bachelor of Arts programmes of the NCCA's undergraduate framework [CMA10], a programme in computer visualisation and animation for the more technically inclined students who aim for a career as a technical director or technical artist and a less technical computer animation programme with a focus on the art of computer animation for students who hope to be employed as artists and animators in the visual effects, computer animation and games industries. This course (worth 10 ECTS credits) is separate from the students' dissertation project, focussing instead on the value of extending practice through reflective experimentation involving a dialogue between student and supervising faculty members and there are similarities between the "Innovations" course and an undergraduate research course that we run for a different degree programme [AAF16].

The duration of this project course is just under 3 months and encompasses two phases: in the first, students explore their chosen domain to formulate a project brief and in the second the students execute the project, finishing with a report that contextualises and critically analyses the work.

Many students use the project to explore new methods that were developed by others, some projects rise above the rest and result in the creation of new knowledge. One such project developed by students of this course during the 2017/2018 academic year was

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the outstanding project described in the next section, developing an improved method for modelling and rendering fruit decay.

3. Withering Fruits

The aim of this project was the development of a parametrised method for simulating drying and decaying fruit, integrating a user interface which allows artist directability and control over the simulation parameters.

The approach developed during the course of the project extends existing fruit decay methods such as that by Kider et al. [KJRB11] and improves the shrinking behaviour of decaying fruits, aiming for photo-realistic results with a greater degree of biological accuracy.

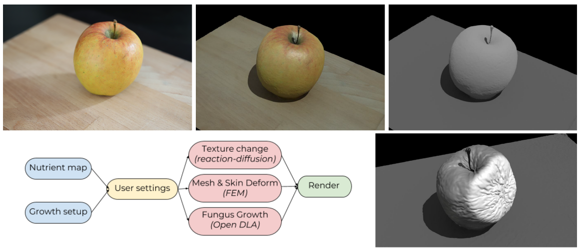

Figure 2: *Clockwise: Reference Photograph; Base Model and Texture (created using photogrammetry); Polygonal Mesh of the Base Model; Wrinkle Map (generated using FEM simulation); System Overview.*

Starting with observation from life, taking reference photographs of a real apple for model construction and texture creation (Figure 2), research for the project began with visual analysis of real life references of a decaying apple over time. This aspect was substantiated by works on mould morphology and properties, biological characteristics [SSM07], as well as more focused research in the domain of computer graphics such as Liu et al. [LCW*12].

The implementation of the process was conducted and assessed during the weekly meetings in order to assure the quality of the project was reaching the targets. The process was divided in the following main parts: mould spread, volume shrinking and surface wrinkles. The mould was based on a reaction-diffusion model, that acted on a texture map which contained information about the nutrient values of the fruit [FLW13]. These nutrient values were based on biological parameters, aspect which greatly contributed to the realism of the results. As the mould values were updated inside the solver, an alpha parameter output for each vertex point was fed into the shader, where an interpolation between the natural and rot texture map was performed. After assessing the implemented method, a user interface was designed in order to allow user customisable simulations in terms of biological and reaction-diffusion parameters, within certain limits. After the first stage of the process was successfully completed and approved, the additional behaviour was added, which consisted in mesh deformation/fruit shrinking [KJRB11]. The chosen approach involved applying per vertex shrinking forces, which acted on a lower resolution model, with an amplitude proportional to the nutrient map previously discussed. This process had user control over the timestep values and extra biological parameters. The resulted mesh was embedded into a Finite Element Method solver, the original high resolution mesh being used as a target. High frequency wrinkles were created, which replicated the organic tissue characteristic to decaying apples.

Upon project completion, the results describing the fruit decay method, were submitted to the ACM Student Research Competiton at SIGGRAPH 2018 where they were presented as a poster [CA18] and subsequently awarded first place in the undergraduate category.

4. Discussion

This project clearly shows what is achievable when undergraduate students engage in 'real' research and work with faculty, which for the faculty member supervising such a project provides the opportunity to explore techniques that they might not investigate otherwise, and working with an outstanding student is a rewarding experience.

From a student perspective, this project was an opportunity to expand and learn how research and implementation of a naturally occurring behaviour should be carried out. It was an extraordinary incentive to analyse and assess the existing body of works in the domain of graphics, and in this particular case, physical simulations involving mathematical models. The resulting research produced believable results and brought improvements to existing methods, both technically and visually.

After the end of the project both student and supervisor spent additional time preparing the work for submission to SIGGRAPH – at a busy time for both – but the end result shows that this was time well spent.

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