Computational Geometry Concept Videos: A Dual-Use Project in Education and Outreach

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Abstract

We present a series of nine Computational Geometry Concept Videos, available on Youtube. The videos are aimed at a general audience and introduce concepts ranging from closest and farthest pairs to data structures for range searching and for point location. The video series grew out of the development of an online graduate course on computational geometry, and the beginning portions of the videos are used in the course to motivate the concept and to tie it to a "real" problem in New Orleans. Thus our videos serve a dual purpose of outreach and education.

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1 Introduction

Video production and consumption are increasing rapidly due to the rise of mobile technologies and social media [14]. In particular, videos are being used often in education [5], and they are a popular and effective format for science communication [15]. In the computational geometry community there are currently only a limited number of videos and those that exist are often too advanced and thus not suitable for use in an introductory class or for outreach. A practical hurdle for making videos is that it is time intensive and thus expensive. One option is to make content that can be used for multiple purposes.

In education, videos are often used in flipped classrooms [1]. And it has been shown that flipped classrooms are especially effective in STEM [4, 7]. Educational videos should be short (though how short exactly remains debated), and thus ideally have a single topic [6]. Of course geometry is especially well-suited for visual exposition. When producing videos for outreach purposes one has to keep in mind that science communication must be appealing [11]. And for this purpose, storytelling is important [3]. In addition, Mayer shows that abstract concepts are much better retained when they are linked to a concrete question [9].

Our contribution is a series of nine Computational Geometry Concept Videos, available on Youtube [8]. The video series grew out of the development of an online graduate course on computational geometry at Tulane University in New Orleans (CMPS 6130 Computational Geometry). Therefore the motivations for the geometric concepts are deliberately New Orleans-themed. The topics of the videos mirror the structure of the course, and thus provide an introduction to basic computational geometry concepts. The online course material uses the beginning portions of the videos as motivation, and then delivers additional graduate course material. The full-length videos [8] are aimed to introduce computational geometry to a general audience.

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2 What did we do

We produced nine episodes, covering basic concepts in computational geometry: closest and farthest pairs in a point set, minimum spanning trees, smallest enclosing circles, travelling salesperson tours, planar graphs and spanners, Delaunay triangulations, Voronoi diagrams, and data structures for range searching and for point location. Naturally, these topics are interrelated; we have opted for making each episode self-contained but included links to other episodes where relevant.

Each episode is broken into sections with different purpose and modalities. We start and end each episode with on-location footage of a “real” problem in New Orleans, for which the geometric concept in that video is relevant. Most of each episode consists of sections in which we define the problem, explore different solutions, and analyze these solutions. These sections were recorded with two cameras simultaneously, giving the option to switch between the speaker and a pen-on-paper visual aid. Finally, all episodes are broken up with at least one short “history” section, in which we place the concept in the literature.

For the online graduate course CMPS 6130 Computational Geometry, we used the beginning of the videos as motivation for the material of a week of class. The topics of the nine videos thus mostly reflect the topics for the first nine weeks of the course (we did not make a video about convex hulls, which were covered early in the course). The course is structured to have a large portion of asynchronous material consisting of a combination of short motivation videos, text, interactive H5P elements in the text, short technical videos (not on Youtube), interactive Geogebra constructions of the geometric concepts, as well as online discussions among students. The course was offered for the first time in Fall 2023 and received high ratings in the student course evaluations (4.82 out of 5 for “Overall, I would recommend this course”).

Thus our Computational Geometry Concept Videos serve a dual purpose (1) for outreach, to introduce a general audience to computational geometry using videos accessible on Youtube, and (2) for education, to build the foundation – and importantly the connection to New Orleans – for an online class on computational geometry.

3 What did we learn

First of all, making the videos was a lot of fun! We got to go to various parks and to Mardi Gras parades, eat snowballs, visit different sites in the city of New Orleans, and even give a cooking lesson. We also took the pen-on-paper perspective a bit further by creating some stop motion animations. And we learned a lot about the history and the background of the topics while preparing for the episodes: for instance, we learned that lexicographically sorted lists were already used by the Babylonians as evidenced by the tablets of *Inaqibît-Anu*, descendent of the deity *Ah’ütu* [12]; that the first mention of the name “Travelling Salesman Problem” was in a now unclassified report for the US Armed Services Technical Information Agency [13]; and that what we now call Euler’s formula already appears in an unpublished manuscript from 1537 [10]. We tried to incorporate such “fun facts” into our videos as well – not only does this nicely break up the more technical parts, but it also gives students and viewers some perspective on the state of our knowledge and its roots, something which is not always self-evident in the western STEM education tradition [2].

While it may be obvious to anybody who has tried it: producing such videos is time-consuming. In total we made nine episodes of on average 25 minutes. Each episode took about 25 hours to produce. A rough production time distribution (per episode):

- Research: 5 hours
- Writing the script: 2 hours
- Recording: 5 hours
- Creating digital animations: 2 hours
- Editing: 10 hours

We do encourage everyone in the community to build on our experience and produce more videos like this. Here are some personal recommendations:

- **Invest in equipment...** You can't fix bad video or audio quality after the fact, and decent equipment is not too expensive. You will likely spend a factor of magnitude more in time.
- **... but don't overthink it.** On the other hand, don't be a perfectionist. We cannot and do not have to compete with the movie industry for production quality. In the end, the most important thing is to just do it.
- **Stay consistent.** For the style of the videos we chose a combination of casual atmosphere and low-key pen on paper. And all episodes have a similar structure. Consistency goes a long way in conveying an air of professionalism, even when keeping production cost low.

4 Conclusion

We found that for the online graduate class, the videos were very successful in connecting the topic of each week to New Orleans, and thus helped the online students feel part of New Orleans and Tulane University.

Computational geometry is an ideal discipline to explain using an audiovisual medium. We hope that this series will inspire others to produce computational geometry videos for a more general audience. Such videos are a good vehicle for outreach at various levels.

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