Virtual Camera Control with the Toric Space: Towards a Visibility-aware approach

18 Oct 2018

Introduction

Virtual camera control is an essential component of many computer graphics applications. The proper selection of viewpoints and the proper design of camera paths are therefore of prime importance to precisely convey intended effects. With the help of the Toric space [1], both novices and experts are able to efficiently manipulate viewpoints as well as perform sequential interpolation while controlling the framing of two actors in screen-space.
The project contains following parts:

- Reading and understanding the article *Intuitive and Efficient Camera Control with the Toric Space* [1] provided with the description.
- Finishing 3 tests with the recommended mathematical tools and methods (see sections 1.1,1.2 and 1.3).
- Writing a report about your methods and results, minimum 2 pages.
- Handing your report, codes and an instruction about the codes.
- Displaying it on your homepage if possible.

1 Description of the problematic

Although the Toric space representation provides a lower dimensional manipulation of the virtual camera, the hypothesis is based on full visibility of both actors during the whole shooting process. However 3D scenes often contain complex geometries that prevent the full visibility of the characters. The very objective of the project is to propose a visibility-aware approach for camera control using the Toric Space with the help of recommended mathematical tools in the Unity3D environment.

Given a simplified assumption of two characters in the scene and some static or dynamic obstacles with a 3D convex shape (such as a capsule or a sphere) occluding the view of one or both characters, your work is ensure the computation of a new camera position every frame that will (i) avoid the occlusion of the characters by the obstacles (whenever possible), and (ii) try to minimize the amount of change in the image space (i.e. minimize the displacements of the characters on the screen in comparing with the initial position). The figure. 1 displays an example with 3 types of obstacles

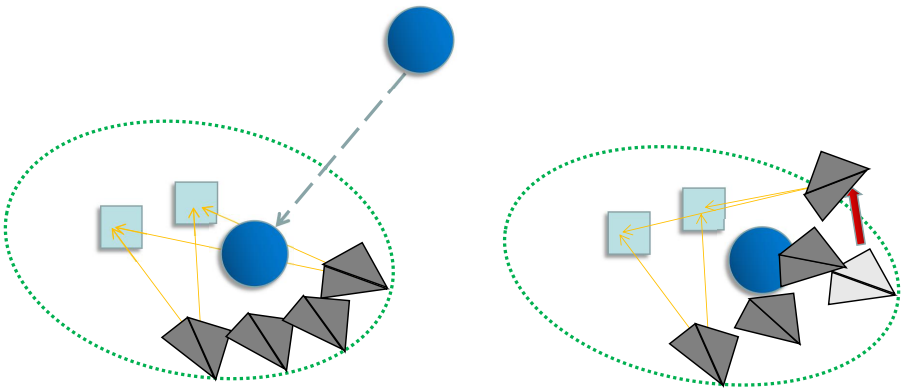

Figure 1: Illustration of a potential obstacle occluding the view of the characters (left), and illustration of two potential cameras that avoid this occlusion (right).

1.1 Task #1: Near camera small-sized obstacles

In order to understand the problematic, and get a hand on Unity3D's features, we first propose a baseline task defined as follows. The general idea is to perform a sampling of the characters visibility (using Unity3D raycasting techniques) around the camera's current position. From the sampling, a decision needs to be taken as to which direction to choose to move the camera. Here techniques such as stochastic local searches can be used to randomly find an unoccluded view. This sampling should be performed in the Toric Space

to avoid strong changes in the image space. This technique is adapted in situations where the obstacle is near the camera with a small size (in relation to the camera screen size).

1.2 Task #2: Near actor or large-sized obstacles

Once you realized the inefficiency and issues related to stochastic local-searching algorithms (computational cost and camera instability), other approaches should be explored. Here we'd like to give you a hint to apply **numerical gradient-descendent optimization** techniques rather than stochastic approaches to solve the problematic efficiently and avoid instability. Remember you can totally benefit from the advantageous condition of having ***convex shape*** obstacles.

1.3 Task #3: Go further? Try it by yourself

Like the joke *Spherical Chickens in a Vacuum*, researchers tend to work under the overly simplified world. We now encourage you to propose funny ideas or even more complicated conditions in the scene with relevant objective of occlusion avoidance.

An exemplary can be solving the Task 2 with an uneven surface or non-convex shape of obstacle, some more sophisticated optimization methods need to be introduced to achieve the goal.

Propose it by yourself, and solve it by yourself. Try to surprise us with your crazy ideas is the final objective of this project or even more.

2 Evaluation Metric

The basic requirement of the results is that the actors have to be visible during the whole shooting process. The obstacle can be in the view but not blocking the two actors' head of the Toric manifold, which means the head of actors in this very case. Feel free to animate and adapt the scene for every task by your own for the purpose of experiment and curiosity, but you should NOT simplify the problem to make it easier.

The grades of all 3 tasks is distributed as follows:

- Task 1, 30%
- Task 2, 40%
- Task 3, 20%
- In addition, the report contains 10%, and the excellent reports and funny idea of adaptation will be shared as the standard with an extra 10% score.

We need to remind you the score is not the objective of this very experiment but the process of modeling the problem and searching for your own way to solve it is.

Suggestion : Search engines and group communication is encouraged during this project however **copy is forbidden**.

Bibliography

[1] Christophe Lino and Marc Christie. Intuitive and efficient camera control with the toric space. *ACM Transactions on Graphics (TOG)*, 34(4):82, 2015.