ORIOLE

A Parametric Solution for Robotic Videography

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Abstract. Oriole is a parametric tool that enables designers to visualize/simulate the robotic videography, the camera path, and the camera aim digitally and in a precise way. Designers using Oriole are able to use Rhino 3D and its node-based visual programming plug-in, Grasshopper 3D-as native design software, to design a robotic camera motion with a fixed or animated target.

Keywords. Robotics; Software Development; Representation; Parametric Design; Videography.

1. Abstract

This paper presents a project-based research study using Oriole—a custom-made plug-in for grasshopper 3D software, as a new tool for robotic videography. Oriole is a parametric tool that enables designers to visualize/simulate the robotic videography, the camera path, and the camera aim digitally and in a precise way. Designers using Oriole are able to use Rhino 3D and its node-based visual programming plug-in, Grasshopper 3D-as native design software platforms, to design a robotic camera motion with a fixed or animated target (Figure 1, and 2). Using a digital model and robotic simulation platforms for different industrial robots such as KUKA, ABB, and Universal, Oriole enables designers to design/create a precise interaction between the robotic “camera” and the physical environment.

Figure 1. Screen-shots of Oriole plug-in simulation platform in Rhino 3D and Grasshopper environment.
By investigating design students’ and designers’ experiences in using Oriole platform, this study demonstrated the potential of a digitally controlled physical robotic camera, not only as a representational tool but also as a new outlook to interactively evaluate the tangible outcome of the design process through the lenses of the robot as an architectural/design-oriented take on Machine-Vision.

2. Introduction

From the early 1990s and by the introduction of digital design tools, the dialogue between digital design environments and physical/analogue design and experience platforms has always been a critical component of the contemporary digital design discourse. By investigating new design possibilities brought into the design conversation, following the notion of “digital design” and almost simultaneously, an increasing desire to duplicate digital design outcomes in the physical world of materiality has become a driver for digital fabrication investigations.

By introduction of robotics in the form of Computer Numerical Control machines (CNC) and later six, seven and eight-axis industrial robotic arms, and through additive and/or subtractive manufacturing methods, the boundary between digital design outcome (digitally designed) and physical replication of it (digitally fabricated) became more and more blurred. Today, and as part of the cyber-physical dialogue of digital design and fabrication, It is almost accepted that we are capable of “translating” any digital design to its tangible duplicates, through digital fabrication techniques. This translation-in the context of this paper, can be understood as bridging between two different mediums of digital design and physical experience of design outcome.

Through this workflow, designers are almost capable of translating every virtually designed elements/components, into the physical space, as means of bringing the digital representation / “proposal”, to form and space as user experience, but there is a significant component from the digital design environment that has not been considered as part of this translation workflow: Digital Camera.

One of the unique components of the digital design environment that usually
gets lost during the “translation” from digital design environment to the physical space is the digital “camera” and curated “controlled” perspectives. Given the importance of the digital camera as part of how designer understands, designs and represents the design and its experience, it seems to be crucial—when it comes to the translation of digital design environment into the physical through robotics, to consider the possibilities of translating “point of view.”

In his book “Robot House” Peter Testa (2017) explains how view/perspective—and ultimately image is not limited to be a representation but can become a design/experience tool itself. The “Impossible Objects” design series by Kruysman-Proto and Curime Batliner (2011), and the “Aether Project” by Guvenc Ozel studio (2013) at University of California Los Angeles are some other examples of similar thinking about spatial qualities of perspective and imaging. Another familiar example of the use of robotic videography to curate an atmospheric spatial effect is the work of Bot and Dolly (2013), a creative robotic studio in designing and shooting special effects of the movie Gravity.

3. Research questions and methods

Developing based upon earlier studies in robotic controlling and creative robotics, Oriole is part of ongoing research that questions two potentials of robotically controlled/manipulated perspectives:

1. Possible new ways of interaction and user experience development with physical/tangible mediums to enhance the continuity of the cyber-physical experience.
2. A new design tool to produce design feedback based on robotically controlled camera in interaction with physical models, as a way to modify the digital design.

To the mentioned questions, there is a need for communication between the digital design-camera in the design software and the robotic camera inside and outside of the computer. On the other hand, and due to the diversity of the possible users, to maximize the usability, Oriole, needed to be adaptable with different controlling platforms for industrial robots including KUKA, ABB, and Universal.

To achieve the goal of adaptability, Oriole can work independent from the robotic/controlling software/plug-ins and act as an addition to the digital simulation. In another world, Oriole uses the digital camera path and converts it into a parametric “animation” to generate a motion path for robot arm (regardless of the robot brand) as a mean of communication between the digital camera and the robot path generator.

Developed for the use in the context of a graduate research studio at Kent State University’s College of Architecture and Environmental Design, Oriole has three main components: (a) Camera Path, (b) Camera Aim, and (c) controlling planes/path for the robot. In addition to these three main components, Oriole can directly generate controlling codes for KUKA industrial robots or can use any other parametric robot controlling platforms such as KUKA|Prc, HAL, and Taco—to name a few, to drive the robot. This adaptability is one of the distinct advantages of Oriole.

For the current research, we produced a platform to use Oriole as a component
of a research studio, using KUKA KR6 R900 Sixx robot arm and with a focus robotic videography as a means of representation. In addition, some students used Oriole-as a method to study formal, spatial, and compositional qualities of the design through the physical model and as a feedback system to inform the digital design (Figure 3).

![Figure 3. Screen-shots from the video footage captured using Oriole simulation plug-in.](image)

We then observed as volunteer designers at Kent State University endeavored to learn how to work with Oriole platform as both representational and design tools. The primary goal of the experiment was to observe the practicality of Oriole plug-in in connection to robotic controlling and design platforms and to make some initial observations about how its use affects the design process. This paper demonstrates how the use of Oriole, enhanced students’ representational techniques and in some cases their design process. Later, this paper discusses the potential applications of Oriole as a digitally controlled physical "design/experience-interface."

4. Oriole: A Parametric Solution for Robotic Videography

As part of its core requirements, Oriole serves as a plug-in for Grasshopper 3D environment—a node-based visual programming add-on for Rhino 3D. Communicating between Rhino 3D design/modeling environment and Grasshopper 3D code-generating platform, Oriole allows for robotic code-generating platform-KUKA|Prc in this paper, to understand the position of the camera and its normal vector in Rhino and send it to the robot-KUKA KR6 R900 Sixx in this research, as KRL code (Figure 4).
4.1. ORIOLE COMPONENTS: CAMERA PATH

As a strategical logic to develop a controlling mechanism for the robotic camera, Oriole follows the logic of almost any animation software platform: Camera path as a way to define camera position/orientation. As part of Oriole plug-in there are two main ways to generate a camera path: (a) Camera path as a curve/poly-line that defines series of positions of the camera on that curve, or (b) Camera plane that determines the location of the camera one point at a time. The significant difference between these two methods can be explained using animation lens and language. In method A, where the path of the camera movement is designed and predefined, based on the given time-window for the “shot” / videography, Oriole parametrically divides the path/curve of the motion into points that later define the position of the camera based on time. In this method—since only the position of the camera is defined, there is a crucial need for defining the “Camera Aim”—discussed in further detail below. Camera Aim, in connection, will define the orientation of the camera (Figure 5). In method B however, Oriole receives numbers of three-dimensionally oriented planes, as a way to identify both the position of the camera, as well as its orientation—through the normal vector of the plane (Figure 5). Although method B has the advantage of independency from the camera aim, it losses the fluidity and continuous quality of the camera path simulation, since each plane has its own position and orientation. In the current version of Oriole, Oriole 1.0, there is a limitation for a maximum of 30 planes/frames in method B.
4.2. ORIOLE COMPONENTS: CAMERA AIM

Based on the Camera Path strategy, and as briefly mentioned above to define the orientation of the camera in relation to its target—especially in camera path method A, there is a need for an aim to define the target of the camera. This possibility becomes even more vital when the focus of the camera is also animated. The Camera Aim component of Oriole plug-in enables the user to not only define the static target of the videography as a way to ensure the precision of the videography but also opens up possibilities for animating the robotic camera as a more dynamic yet controlled point of view (Figure 6).
4.3. ORIOLE COMPONENTS: CONTROLLING PLANES | PATH

To move the robot arm-KR6 R900 Sixx in this research, we used KUKA|Prc Plug-in (Braumann, and Brell-Cokcan, 2015). To communicate data from Camera Path and Camera Aim components to KUKA|Prc plug-in, there is a need for two sets of information: (a) position and (b) orientation. Mathematically, a plane with an origin-center of the plane and its normal vector, can host both of these parameters. As the last main component of Oriole and to generate motion-commands for the industrial robot arm, Oriole converts the three-dimensional information of position and orientation, into sets of plane information. Later, KUKA|Prc plug-in uses these plane data sets, to generate KRL code/commands to animate/move KUKA robots.

5. Operation and Testing

To test the plug-in, and as part of a graduate research studio at the College of Architecture and Environmental Design at Kent State University, we used Oriole as a representational tool to videography the physical models of the projects as a way to communicate the digital “design-camera” with the audience. During and as part of the design process, each student has been asked to digitally develop a fly through/digital design-camera in Rhino 3D that represents their project the best. Students used the design-camera as a tool to focus on different formal and topological qualities of their design/digital model, as well as hiding some other ones. Through these back and forth processes and negotiations between the digital design and the digital design-camera/point of view, students developed a digital model of their project in Rhino 3D environment and using digital fabrication techniques, produced physical models of those projects.

Later in the process, and to communicate the representational digital design-camera path with the audience-to fully translate the digital experience into a physical one, each student started to develop a robotic camera path via Oriole. Based on the different camera paths in Rhino 3D, students decided to use method A (path-based simulation) or method B (plane-based simulation) in Oriole as explained above. By precisely assigning the same points of view to Oriole planes or path set-ups, as the next step to design the final robotic camera path, each student defined one static or dynamic aim for the camera.

Ultimately, each student developed a camera path as a set of plains with origin and normal vector that defines the location and orientation of the camera. For KUKA robot to understand its particular configuration-different from CNC machines with G-code and because of the six-axis of freedom, it is necessary to provide two sets of information: X, Y, and Z for position and A, B and C for orientation. The origin of Oriole plains, defines the location of the 6th axis of the robot-X, Y, and Z for the end effector of the robot in KRL code, and the normal of the Oriole plane, defines the orientation and at where the 6th axis points-the A, B and C parameters of the KUKA robot in KRL code (Figure 7). Using KUKA|Prc plug-in for grasshopper 3D, this information later converted to KRL code that is understandable for the KUKA robot.
Figure 7. Using KUKA|Prc plug-in for Grasshopper 3D, Oriole Plane information can be translated to KRL code for robot position and orientation.

After generating the KRL code for KUKA robot arm, students used their physical models and positioned the model in a similar relationship with the robot as digitally simulated. With the real camera mounted on the KR6 R900 Sixx robot and the camera path loaded to the robot controller as KRL code, each student studied their physical model through the physical replication of their digital design-camera: a physical model. As a result of this set-up, the audience of the project could also experience the project in its physical representation and through a controlled perspective (Figure 8).

Figure 8. An example of robotic videography using Oriole plug-in for Grasshopper 3D.

As the next step of the design process and through precise matching of the digital design-camera and the physical robotically controlled camera, some of the students started to study their physical models to translate some of the material and fabrication qualities back into the digital model. Keeping the same point-of-view
more or less correlated in the digital file and the physical set-up, enabled students to acknowledge the difference and some imperfections from the 3D printing or CNC milling process, and use them as drivers for design decisions digitally (Figure 9).

![Figure 9. Feedback from physical videography and 3D printing resolution informed the digital design as feedback. The surface detailing is a result of this back and forth.](image)

6. Conclusion

Oriole as a parametric robotic videography plug-in affects the design and representation process from three different viewpoints:

6.1. ORIOLE AS A REPRESENTATION TOOL

At its minimum—which was the main focus of this paper, and as a platform, Oriole enables designers to document the physical design and representation of the design, precisely and with almost the similar “resolution” of digital design environments. Curating highly accurate perspective views as well as the introduction of high-level of precision in relation to time, makes Oriole a tool that can be used as a representational tool to document the project or to conceptually amplify some aspects of it.

6.2. ORIOLE AS A USER-EXPERIENCE PLATFORM

Due to its tangibility, Oriole is a platform that negotiates between qualities and freedom of point of view in digital design environment and materiality of the physical world. As a user-experience platform, Oriole can become a curated/curate-able point of view in the hands of the designer, from the story-telling point of view. Through its controller camera, Oriole becomes a bridge between the designer and the audience, where the designer not only defines the design but also “directs” the audience on how to experience the design, through pre-designed views.

6.3. ORIOLE AS A POST-DIGITAL DESIGN TOOL

Because of its direct and close connection to the digital design environment, Oriole as cyber-physical videography tool becomes a platform to carefully study difference and friction between a digital “thing” and its physical replica. Matching the perspective and the camera path in both mediums, Oriole opens up the
possibility for closer study of materiality, resolution, miss-fit and post-digital materiality, to name a few. Components from the current research looked into some of these possibilities as students started to reuse the aesthetics of the robotically videographed model, back into the digital design process.

7. Limitations and Suggestions for Future Research

The main limitation of this study was the limitation on the scale as the research was limited to the use of KUKA robot KR6 R900 Sixx. From both technical and conceptual viewpoints, it would be beneficial to examine the research agenda of this paper—from a representational point of view, in different scales. Oriole as a parametric videography tool/plug-in for Grasshopper 3D is fully functional and tested. At this point of this ongoing research and as part of the future research plans, we are interested in examining Oriole in more depth and as a user-experience tool in conjunction with augmented reality tools. Another component of Oriole that needs a lot more studies in depth is its use as a post-digital design tool. Having the technical difficulties solved, we are interested in testing Oriole in more conceptual set-ups and not only as a translator of digitally pre-defined camera paths but as a tool through which explore the physical model/space. We are currently working to enhance Oriole as a plug-in by including some of these feedback components as part of the process and by introducing some other parameters from digital design environments such as focal point of the camera and lighting.

References