3D Sketching for Multi-Pose Products: An Interactive Showcase

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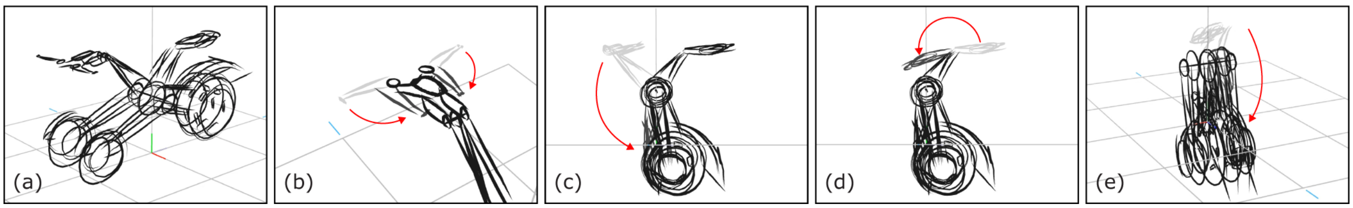

Figure 1: (a) A 3D sketch of a concept foldable bike produced using our system. Sequentially, (b) the bike handle, (c) the front of the bike, and (d) the back of the bike are folded into (e) the portable form.

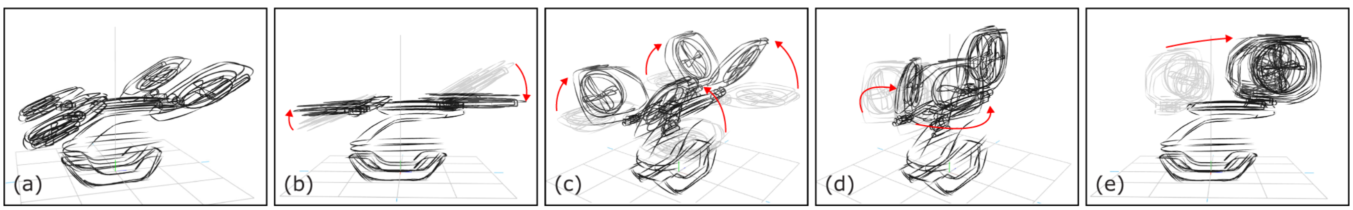

Figure 2: (a) A 3D sketch of a concept flying-car produced using our system. (b-e) The four thrusters perform a series of maneuvers to become fully folded after landing.

ABSTRACT

2D perspective sketching is an essential tool for designers during the early stage of design. However, for products that have moving parts and take different poses during usage, 2D perspective sketching can be painstaking and time-consuming. In this interactive showcase, we present a 3D sketching system for multi-pose products. Our system lets designers easily sketch 3D curves, and part, rig, and pose them. We showcase that, with interactions that closely resemble traditional 2D perspective sketching and the physical manipulation of an articulated object, designers can quickly try many different form and movement ideas in 3D during the early stage of design.

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1 INTRODUCTION

Multi-pose products have moving parts and take different poses during usage. However, sketching complex forms in different poses and perspectives can be painstaking and time-consuming even for experts, during the early idea exploration stage. Moreover, the actual movement can only be seen much later in the design process, with elaborate 3D modeling or physical prototyping, at which point unexpected or unsatisfactory outcomes can literally send designers back to the drawing board.

We showcase a 3D sketching system for multi-pose products [Lee et al. 2020] that lets designers quickly try many different form and movement ideas in 3D earlier on in the design process. Using our system, designers can easily sketch, part, rig, and pose 3D curves (Figure 1, 2). Here, 3D sketching refers to authoring 3D forms through digital pen drawing input, which can be a powerful tool in the hands of trained designers [Bae et al. 2008; Kim et al. 2018; Kim and Bae 2016].

Previous studies suggested systems that help the user animate 2D sketches [Davis et al. 2008; Kazi et al. 2014] or construct a movable 3D model from multiple 2D sketches [Shao et al. 2013], and systems that use 3D sketches to determine optimization parameters of a generative design algorithm [Kazi et al. 2017]. Our system focuses on a kinematic 3D sketching workflow for designers to ideate and iterate on multi-pose products, through interactions that emulate traditional 2D perspective sketching and physical manipulation of an articulated object.

2 SYSTEM DESIGN

In our system [Lee et al. 2020] the designer sketches, parts, rigs, and poses in any order and any number of times (Figure 3).

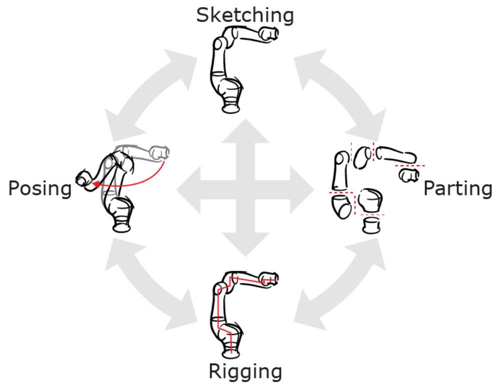

Figure 3: Our system's kinematic 3D sketching workflow.

2.1 Sketching

The designer first sets up a plane or a sphere, and then draws curves that are projected onto it. A plane is set up by tapping the pen tip on a grid line or a curve. Doing so marks a point in space. When one, two, or three such points are marked, a plane including those points is created [Kim et al. 2018; Kim and Bae 2016]. A sphere is set up by tapping on a grid line or a curve and dragging the pen tip. When the pen tip lifts up, a sphere whose center is the tapped point and surface includes the lifted point is created (Figure 4a).

2.2 Parting

A part is created by creating a part marking tab and entering it. Initially, all existing curves appear unmarked. The designer marks curves by crossing the pen tip over them. The designer then trims them with a precise eraser that can unmark portions of the curves, or a rough eraser that can unmark the entire curves. This process modifies only the information regarding which portions of which curves belong to a particular part; the shapes of the underlying curves remain unmodified (Figure 4b).

2.3 Rigging

A hinge joint is created by setting up a sphere that includes a point on a parted curve on its surface, and then sketching a desired trajectory of that point on the sphere. The system then creates a hinge joint with a position and an orientation that most closely approximate the trajectory. Using the posing method (Section 2.4), the designer then moves the part against another part along the trajectory, to demonstrate the joint's range of motion (Figure 4c).

2.4 Posing

The designer performs forward kinematics posing with two touches. The first touch selects the part to be held still. The second touch selects the part to be moved. Among joints connecting all the parts in between the still and moving parts, only the joint that is directly attached to the still part is enabled. With the first touch fixed, the second touch-drag rotates the enabled joint (Figure 4d).

Likewise, for inverse kinematics posing, which enables simultaneous rotation of multiple joints, the designer selects the still and moving parts as above. Then, while holding the first touch, the second hand makes a mid-air pinch gesture. The translation and rotation of the moving part follow those of the pinched hand, and all other parts are posed through inverse kinematics. Clutching is achieved by repeated pinching and unpinching (Figure 4e).

3 INTERACTIVE SHOWCASE

Our implementation uses the Unity game engine, BioIK, an inverse kinematics solver for Unity [Starke et al. 2017], and a Leap Motion hand-tracking sensor. Our system runs on pen- and multi-touch-capable digital tablets, such as the Wacom Cintiq Pro 24 Touch.

In the interactive showcase, a product designer uses our system to rapidly produce many 3D sketches of multi-pose product concepts during the exhibition. Some of these concepts are: a drone with a folding mechanism; a multi-joint robot arm; and a self-driving car with moving interior and exterior parts.

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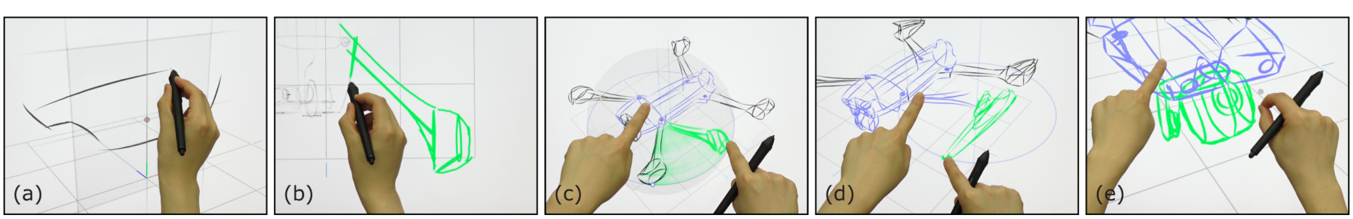

Figure 4: (a) Sketching, (b) parting, (c) rigging, (d) forward kinematics posing, and (e) inverse kinematics posing in our system.