

# Fast 3-D printing of cephalopod beaks utilizing software oriented techniques

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## Abstract

The beak which is the feeding organ of cephalopods contains extremely rich ecological information. To understand its function in different species the research to the 3-D morphology is essential. In this article, a full workflow of 3-D model restoration of high-fidelity cephalopods beak, based on software-oriented techniques, was established. To begin with, take an upper beak of cuttlefish *Sepia pharaonis* for example, a group of isometric view from different orientations for modeling references could be obtained synchronously, in few images, with triangular prisms around it. The software Photoshop © was applied then to extract the contour of the beak hence to build the 2-D reference gallery. Thirdly, the software ZBrush 2020© was exerted to create the beaks in 3-D digital form as realistic as possible, based on reference gallery we built, and printed. These digital-twin models were compared with their prototype beaks and that of big fin reef squid to verify their accuracy. The aim of this study was to provide a feasible method for digital modeling of small organic objects like cephalopod beak that is accurate, and fast enough to support scientific research and popular communication.

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