A Digital (3D) Reconstruction of a Lost Planetarium: A Finishing Touch to the Antikythera Mechanism

Ioannis S. Diolatzis, University of the Aegean, Mytilene, Greece
Gerasimos Pavlogeorgatos, Department of Cultural Technology and Communication, University of the Aegean, Mytilene, Greece

ABSTRACT

After many years of research, it has been concluded that Antikythera mechanism is a more complicated device than initially was thought. Recently, the rapidly increasing development of 3D modeling and simulation software, resulted in attempts to recreate the mechanism’s 3D construction. These 3D replicas are based on advanced knowledge, gathered by the study of the mechanism remnants or the deciphered inscription on its surfaces. The latest decrypted inscriptions on the back door of the mechanism refers to planetary motion, which might be illustrated by a planetarium formation, which is absent from the remains of Antikythera mechanism. The authors propose a 3D reconstruction of this alleged planetarium, as a possible sequence of the existed mechanism’s remains, compatible with the surviving inscriptions. Specifically, the authors introduce a lot of constructional differentiations compared to the other suggested, focusing mainly on measurements accuracy which this planetary system could perform.

KEYWORDS
3D Modelling, Antikythera Mechanism, CINEMA 4D, Geocentrism, Planetarium, Planetary System, Planets, Rigid Body Simulation, UNITY 3D

INTRODUCTION

In 1901, some sponge divers, pulled out from an ancient Roman shipwreck near the coast of Antikythera island, pieces of a corrupted geared construction. After a more careful examination of the remnants, it was found that these pieces (fragments) belonged to a mechanism which since then was called Antikythera mechanism. Seven of the main survived fragments of this mechanism named from A to G and were dated around 150–100 BCE. In 2005, after the application of two revolutionary technological methods, on Antikythera mechanism, many constructional details came to light. The methods been applied are: a) 3D x-ray computed tomography (CT) by X-Tek Systems Ltd and b) polynomial Texture Mapping (PTM) by HP Labs. In the mechanism remains identified more than 30 gears meshed in complicated combinations, while engraved symbols and letters on the fragments’ surfaces were decoded. Since then scholars have concluded that this mechanical construction was
consisted of an advanced gearing system, and it was capable of making astronomical calculations as well as capable of predicting astronomical celestial phenomena.

A decoded text on the back face of the Antikythera mechanism reveals many details about the characteristics and the functional capabilities of this amazing gearwork machine. According to (Anastasiou et al., 2016) “The texts give data on synodic cycles for the five planets, and it may be conjectured that lost lines described the behavior of the Sun and Moon.” According to (Freeth & Jones, 2012) there is a deciphered text in the back cover of the mechanism where unfinished words inside fragmentary expressions show names of the five known planets. Particularly noticeable are the repeated words (σφαιρίων) “little sphere”, one for every planet and (κύκλος) “circle” where the little sphere possibly belongs to.

All the above references testify that possibly the Antikythera mechanism, could have a constructive formulation, on its top, like a kind of planetarium. This planetary compartment is completely absent from the remains of the mechanism found in 1901. Speculated models of this planetary synthesis, have already been made and they all use the available space between the sun gear b1 and the top of the mechanism. The gearing of Antikythera mechanism was hosted inside a wooden case consisted from a front and a back door, engraved with the previously referred deciphered texts. Researchers have already presented various models of Antikythera mechanism equipped with planetary systems. In most of them, motion seems to be simulated by epicyclic gearing trains based on the famous “epicyclic theory,” which was known in the era Antikythera mechanism was constructed. Although the implementation of this theory gives satisfying results for planets with negligible eccentricity, fails to demonstrate satisfactorily the motion of planets with considerable eccentricity, like Mercury or Mars (eccentricity of Mercury orbit: 0.205 and eccentricity of Mars orbit: 0.0935). On the other hand, the gear couple of classic “deferent–epicyclic model” limits gear combinations due to the restricted available area and in some cases (especially for superior planets) is not so reliable. For these reasons, models which are using this epicyclic couple, give a planetary motion illustration lacking in measurement accuracy though. Moreover, in Antikythera mechanism remnants, there is a sophisticated device with code name “pin & slot” which regulates the rotation of Moon pointer to simulate the abnormal Lunar rotation around the Earth, using Hipparchus’s eccentric model. According to (Moussas, 2009) “The difference between Kepler’s predictions on the angular velocity of the Moon during the month and the mechanism’s prediction is of the order 1/400…” The fact that moon’s eccentricity (0.0549) is 3.7 less than Mercury’s eccentricity which is 0.205, shows that the constructor could possibly use the same ellipse simulation for planets with considerable eccentricity like Mercury and Mars.

Particularly interesting is the constructor flexibility of handling complex gear combinations, to drive the desirable ratio between the meshed gears. According to a published article written by the authors “For example, in the moon train there are six gears used to transmit the rotation to the lunar pointer.

Specifically, this arrangement starts from gear e2 which is rotating with uniform motion and ends to b3 which is rotating with non-uniform motion in the following order: d₂ → e₂ → e₃ → k₁ → k₂ → e₆ → e₁ → b₃…” (Diolatzi & Pavlogeorgatos, 2019b) (see Figure 1)

The scope of this research was to design a geocentric planetarium display on the top of Antikythera mechanism, combining suitably two contemporary theories (theory of epicycles or epicyclic theory and theory of eccentrics or eccentric-cycloidal theory) formulated in that time. Authors decided that the final product should be a digital 3D reconstruction of an integrated planetary system compliant with the characteristics of the Antikythera mechanism. The whole construction should be composed of sophisticated epicyclic arrangements in order to be accurate and compact as much as possible.
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