Ancient Egyptians and the binary system

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Abstract

In this article I show some evidence that the binary system in the form presented by Gottfried Leibniz in the 17th century was already known to Egyptians at least since 2580BC. Detailed analysis of the Great Pyramid dimensions, also known as Cheops Pyramid, reveals reoccurring 9-bit binary sequence. It is rather doubtful that such sequence appears by accident.

Many ancient cultures exhibited an interest in science, especially mathematics and astronomy. For instance, we know that ancient Babylonians (around 2000 BC) discovered fractions, quadratic and cubic equations and used sexagesimal, which is a numerical system with a base of 60 introduced by Sumerians. Nowadays, we still use this system and thus we have 60 seconds in a minute and divide a full angle into 360 degrees. In Chinese Yi Jing, also known as Book of Changes, (around 1000BC) a binary notation is shown. On the other hand Egyptians are known for their fractions and so-called Egyptian multiplication which is closely related to the binary system. In this short article I would like to show some evidence which could suggest that ancient Egyptians where fully aware of the binary system in a form described in the 13th century by Ramon Llull (1232-1315/16) and in the Early modern period by Francis Bacon (1561-1626) and Gottfried Wilhelm Leibniz (1646-1716).

Undoubtedly, the Giza Necropolis is on of the greatest achievements of the ancient Egyptians with its tree monumental pyramids build for three pharaohs: Cheops, Chephren and Menkaure. Many years ago I found an interesting relation between dimensions of the Great Pyramid written in binary system, which I would like to share in this paper.

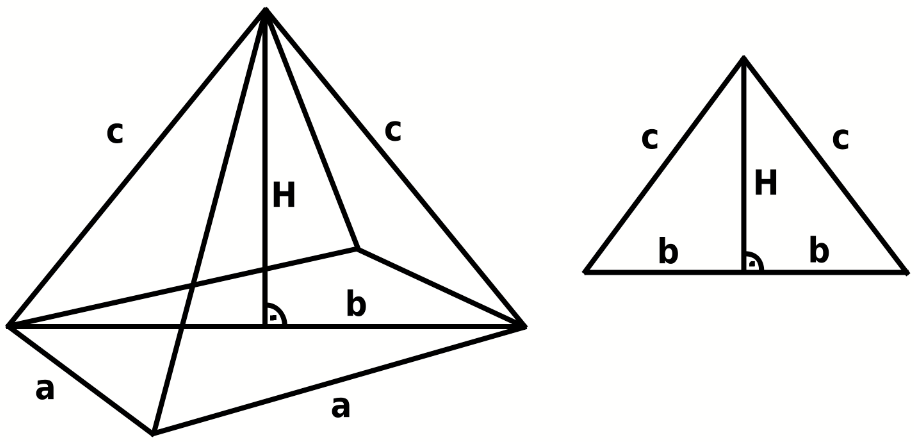

Figure 1: Sketch of the pyramid.

In figure 1, a sketch of the pyramid is shown. For the Great Pyramid of Giza (i.e. Cheops pyramid), which was build around 2560BC, the dimensions are as follows $a = 230.34\,\mathrm{m}$ and $H = 146.7\,\mathrm{m}$. It means that the diagonal of the base is approximately equal to $2b = 325.75\,\mathrm{m}$, so $b \approx 162.87\,\mathrm{m}$. Using Pythagorean equation, which was probably already known in a simple form those days, we get $c \approx 219.20\,\mathrm{m}$. Finally, rounding to the integer values and expressing them in binary system yields

$$\begin{aligned} b &= 163\,\mathrm{m} \quad 10100011 \\ H &= 147\,\mathrm{m} \quad 10010011 \\ c &= 219\,\mathrm{m} \quad 11011011 \end{aligned}$$

Now, take a look at the triangle formed of a diagonal of the base ($2b$) and the two edges c of the pyramid (Fig. 1). Height of the triangle is H. We express the lengths of the edges and the height in binary system and write it from top to bottom. We do the same with the lengths of two halves of the diagonal, writing them from left to right like in Fig. 2.

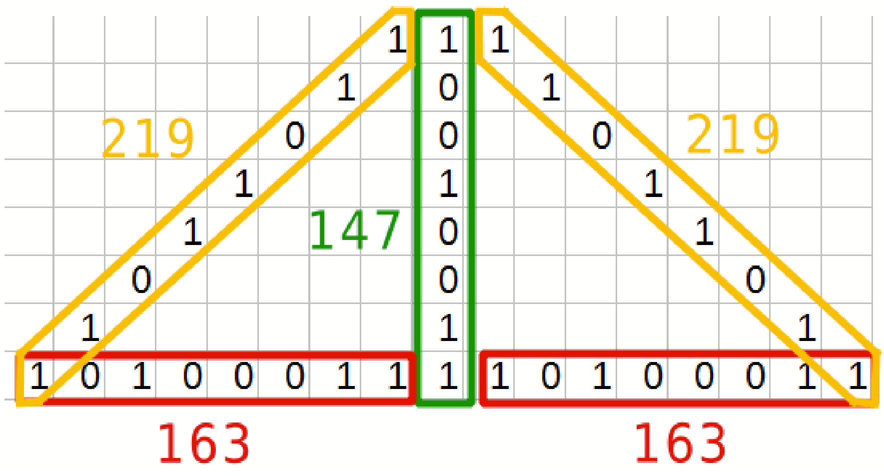

Figure 2: Dimensions of the Great Pyramid expressed in binary system.

At a first glance it seems ordinary, but when we take a closer look the same sequence 111101000 appears while reading digits from left to right and row by row (Fig. 3). This is a little bit surprising, especially because it is very hard to find any other sequence which is symmetric and repeated in this way gives lengths from which we can form a right angle triangle.

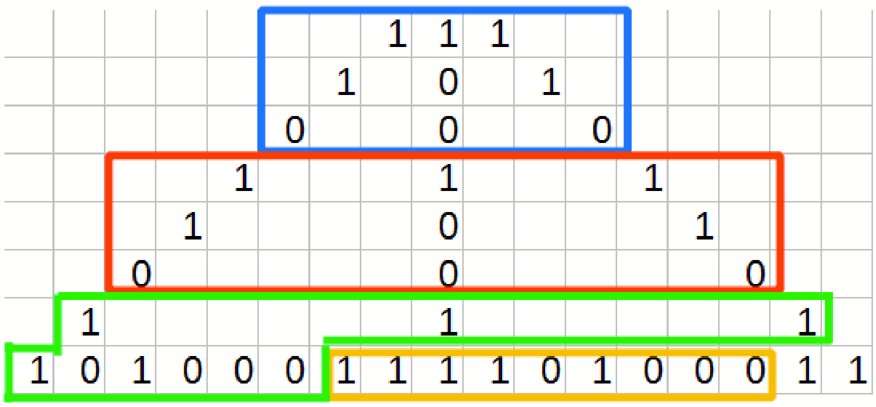

Figure 3: Dimensions of the Great Pyramid expressed in binary system with the reoccurring sequence 111101000.

In the Pyramid of Chephren the same sequence appears but not in such an explicit form. For instance the length of the edge is 209 m which in binary system can be written as 1101001. It is a continuation of the sequence started in the diagonal of the Cheops Pyramid base. Other appearances of the sequence also occur in the dimensions of the Pyramids of Chephren and Menkaure but are not so obvious. It is rather doubtful that these occurrences where intentional. On the other hand, it seems that the dimensions of the Cheops Pyramid and their binary representations are not accidental. The binary sequence 111101000 corresponds to the number 488 in decimal system, which is 0x1E8 in hexadecimal, 750 in octal system and 88 in sexagesimal system. I doubt that the number itself had a special meaning to the Egyptians or had other purpose than to involve the binary system into the design of the Cheops Pyramid and by it to increase its greatness. As it was mentioned before, it is very hard to find an appropriate sequence which gives reasonable dimensions from which a right triangle can be formed. To me it looks rather like an interesting use of the binary system and partial proof that the ancient Egyptians were aware of the binary system in the form that we use today. It is rather impossible to accidentally build such a monumental construction which dimensions are so closely connected to the binary system by reoccurring 9-bit sequence.