The Development of a Tangram Family

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This article presents a family of Tangram-like puzzles, found by exploring other possible sets of pieces which are similar to the set of seven traditional Tangram pieces. The resulting Tangram variations are interesting in their own right, and can be combined into a set of twelve pieces to create additional puzzles.

1 Introduction

The well-known Tangram puzzle consists of the seven pieces shown in Figure 1, with the goal being to arrange the pieces to form a square or other specified silhouette shape. The standard set consists of five *triangles* (T), one *square* (S) and one *parallelogram* (P).

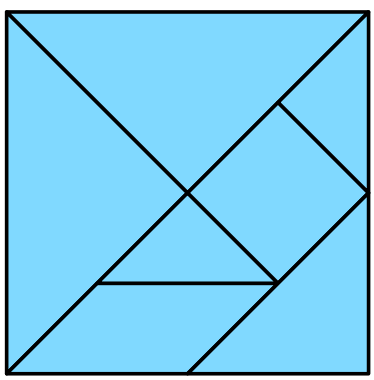

Figure 1. The traditional Tangram set.

Tangram has a long history, possibly originating in China a millennium ago [1] or even earlier [2], and became popular in Europe in the 19^{th} century. Much has been written about the mathematics of the set [5, 6] and many collections of target shapes have been released [2, 3, 4].

Dekking [7] investigates the many different shapes that can be made with the traditional set. In 1976, this inspired my good friend Johan Siders and myself to look in the other direction, and experiment with differently sized pieces in the traditional shapes. Were the specific Tangram pieces special, or could some other combinations of shapes and sizes also produce similarly interesting puzzles? Would it be possible to improve on the original design?

Early results from these investigations were published in Dutch journal *Natuur & Technik* in 2002 [8] and a series of short pieces in *Cubism for Fun* in 2010 [9, 10] and 2011 [11, 12]. This paper summarises these earlier findings, to present the 'complete family', and adds some recent updates.

2 Sets with Five Triangles

We initially considered similar piece sets with distributions similar to the traditional set (i.e. five triangles, one square and one parallelogram) but with differently sized pieces. Our first observation was that the Tangram pieces can all be divided into *isosceles* or right-angled triangles of equal size, as shown in Figure 2. This gives a convenient unit of measure that we call *basic triangles* (BT) with which we can make calculations about the total area of given piece sets. For example, the pieces in the standard set add up to $1+1+2+2+2+4+4=16$ BTs.

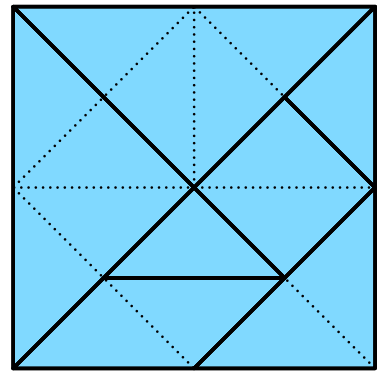

Figure 2. The Tangram divided into triangles.

Pieces can be aligned two ways, with the short side of each BT aligned with either the grid or its diagonal, as shown in Figure 3. A square formed by two BTs aligned with the grid (left) will have a unit side length of u, while a square formed by four BTs aligned with the diagonal (right) will have a unit side length of $\sqrt{2}u$. Using BTs rather than Euclidean area simplifies area calculations.

2.1 Square Target

We were initially interested in finding piece sets that pack into the traditional square, rather than the many thousands of more exotic Tangram shapes that have been published. We therefore considered how many BTs will fit into squares of different sizes.