Zen and the Art of GIS:

Visualising what can't be seen

R. A. Wadsworth[1]

[1]Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE28 2LS, UK
Telephone: +44(0) 1487 772433
Fax: +44(0) 1487 773467
Email: rawad@ceh.ac.uk

1. Introduction

A Japanese *karesansui* garden (a "dry landscape garden") is more usually referred to as a "Zen garden" in the West[1]. A *karesansui* garden contains groups of rocks in a "sea" or "river" of raked gravel; the most famous example is at Ryoan-ji Temple[2,3] near Kyoto where 15 rocks are arranged in five unequal groups.

The *karesansui* garden at the Ryoan-ji Temple was started during the Muromachi Period (1333-1573) the garden's designer is uncertain. The current garden may have more stones than the original design, (the back wall is certainly a later addition). Although there have been famous monk-gardeners it was not strictly speaking a suitable activity for a Buddhist monk; *"People practicing Zen should not construct gardens. In a sutra it says that the Bodhisattva Makatsu, who wanted to meditate, first totally abandoned the this-worldly life of making business and gaining profit, as well as growing vegetables... Is not (Muso's life of making beautiful and admired gardens) far removed from the meaning of the sutra?* Muromachi-era monk at Toh-ji (translated in Kuitert (2002)). The term "zen garden" first appears in print in 1935 in a book published in California, and the Japanese term for "Zen garden," *zen-teki teien*, didn't appear in Japanese-language literature until 1958 (Kuitert ibid).

There has been considerable work on why the arrangement at Ryoan-ji is aesthetically pleasing. Van Tonder et al. (2002) and van Tonder & Lyons (2005) discuss the arrangement from a scientific, visual processing perspective. One of the features of this garden is the claim that wherever you sit on the veranda you can only see 14 of the 15 rocks, different rocks are obscured from different view points. Only on attaining "enlightenment" can all the rocks be seen.

As the reference to Zen in connection with *karesansui* gardens is probably spurious, the question arises as to whether the statement about the visibility of the rocks might also be "poetic license". Although there are many photographs of the gardens on the Internet there are very few that encompass the entire garden in a single image and those that do lack sufficient detail to be able to count the stones with any confidence. Irrespective of the actual Zen quality of the Ryoan-ji garden we were inspired to consider whether it was theoretically possible to arrange irregularly sized objects so that when viewed from any

[1] http://www.rothteien.com/superbait/zenviewpoints.htm
[2] http://en.wikipedia.org/wiki/Ry%C5%8Dan-ji
[3] http://www.ryoanji.jp/

point within a pre-defined “envelop” (in our case along one side and one edge of the garden) there was never a position where *all* the objects were visible and there was never a point where *more than one* object was hidden.

This paper describes an attempt to develop a methodology to determine the invisibility of objects in a group. It therefore forms a counter-point to the more normal visualization question posed in GIS of determining visibility and viewsheds. We speculate that the quality of “obscurity” might have applications in making the design of large features in the landscape, such as wind farms, more aesthetically appealing.

Figure 1 (taken from van Tonder et al 2002) illustrates the basic layout of the Ryoan-ji garden and Figure 2 a photograph of most of the garden. In figure 1, the grey shading in the background represents the medial-axis transformation which is used in visual processing. Van Tonder’s argument is that the branching nature of the medial axis pattern represents a natural pattern and hence makes the arrangement attractive; whereas a symmetrical or regular arrangement of the stones would produce an unnaturally regular pattern and hence a less pleasing pattern.

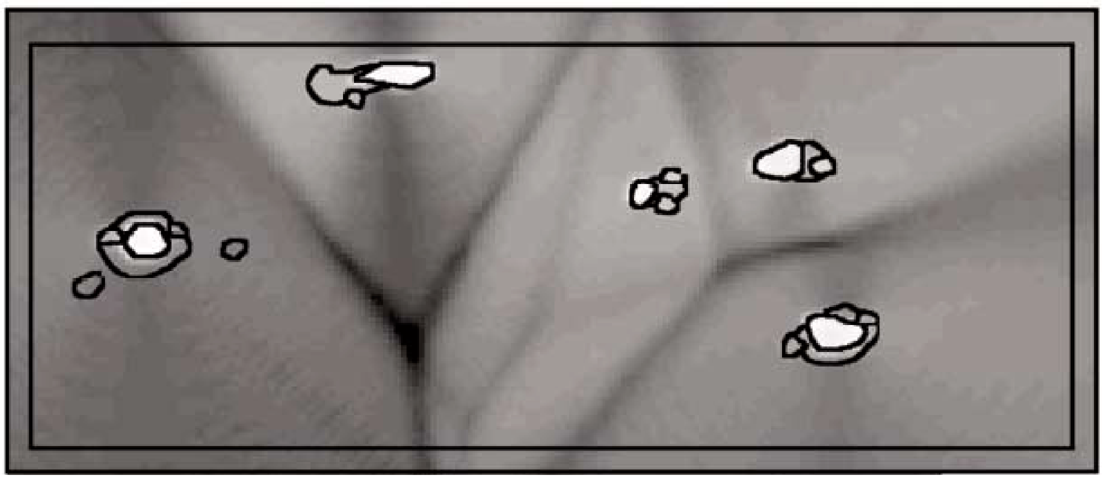

Figure 1. The layout of the Ryoan-ji dry garden (from van Tonder et al 2002). Background represents the medial axis transformation.

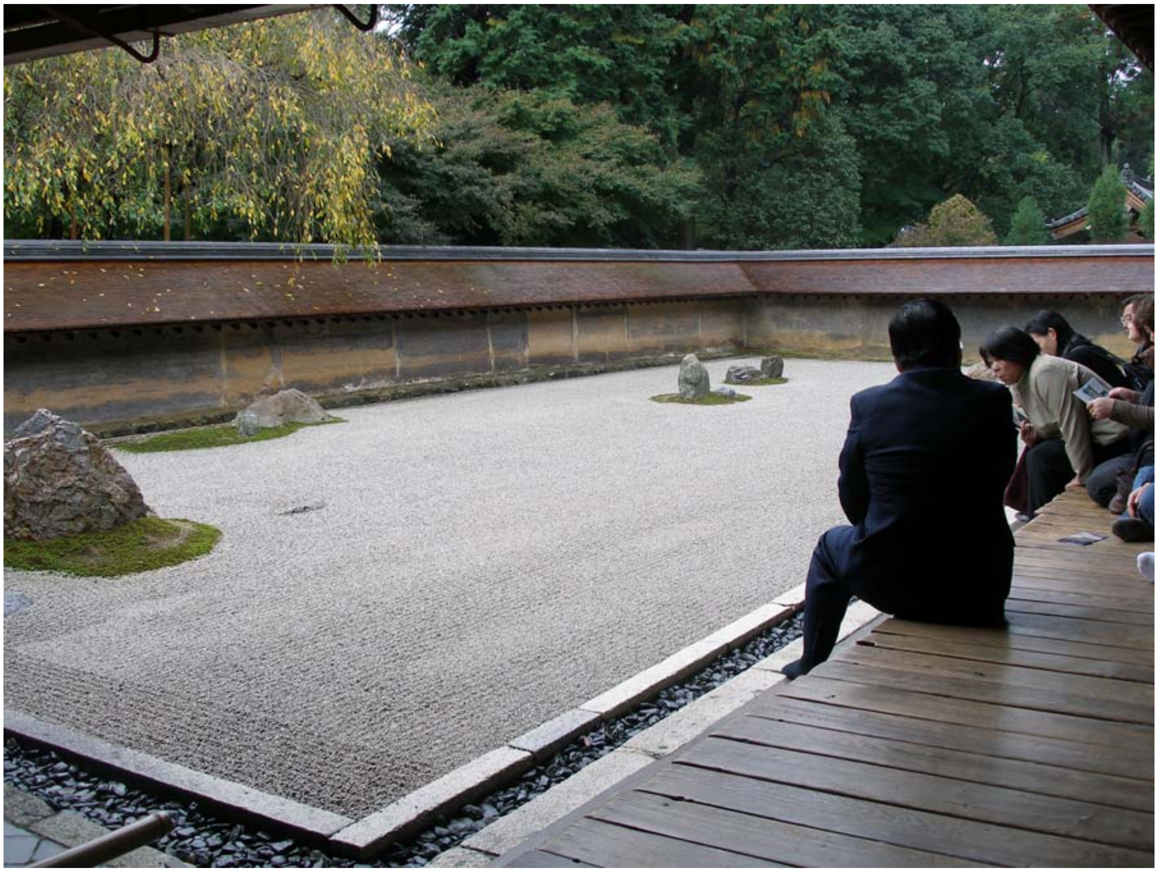

Figure 2. the Ryoan-ji dry garden (© Dr. Ross Hill)

2. Methodology

Stones are approximated as rectangular blocks with varying length, breadths and heights or as cubes; the blocks are arranged in a rectangular field such that they do not intersect each other. To estimate the "fitness" of a pattern (arrangement) we first select discreet fixed points within the viewing envelope (in this case the points are one meter apart, 1.5m above ground level and 1.5m from the edge of the garden along the "south" and "east" edge of the garden). From each viewing point, the number of visible stones is calculated using a z-buffer approach. If exactly one stone is invisible, a counter is incremented by one; the fitness of a pattern is the proportion of view points where exactly one object is invisible. A random arrangement of objects in a field is unlikely to result in a pattern with a sufficiently high fitness; application of simple Monte Carlo techniques typically took several hundred tries to reach fitness levels above 0.8. Two evolutionary programming techniques were investigated, SA (simulated annealing) and GA (genetic algorithm). The GA approach was more successful and the pseudo-code is provided below (figure 3).

1. Fifteen randomly sized objects are specified.
2. A parent population (~100) is generated by:

    2a. specifying 15 random locations (using a uniform random deviate in x and y).

2b. checking whether any objects overlap and moving one (chosen at random) if they do overlap.
2c. from each discreet view point
  use a z-buffer to estimate visual overlap
  count the number of invisible objects
2d. calculate the proportion of view points where exactly 1 object is invisible.
2e. if the proportion (fitness) is less than 0.5, repeat steps 2a-d (Generally ~30 attempts).

3. Until a "perfect" solution (fitness = 1.0) is found or 100 generations have been undertaken.
   3a. <u>crossover</u> new "offspring" are generated by selecting two existing individuals (say A, B) at random, a random cross-over point is generated as the mth object, one offspring consist of the locations of objects 1:m from A and m+1:15 from B, the other offspring 1:m from B and m+1:15 from A.
   3b. <u>mutation</u> #1. one object is selected at random and moved (the distance moved is randomly selected from a Gaussian distribution).
   3c. <u>mutation</u> #2. with a given probability the location of two objects is swapped.
   3d. <u>viability</u> of each solution is checked to make sure objects do not overlap; any overlap is resolved by moving objects.
   3e. <u>fitness</u> of each of the new solutions is calculated (2c,d).
   3f. <u>tournament selection</u> takes place (two individuals are selected at random; the one with the highest fitness is taken through to the next generation).
4. write out the best solution.

Figure 3. Pseudo-code of the Genetic Algorithm Approach

3. Results

Figure 4 illustrates an arrangement of irregular blocks and Figure 5 an arrangement of different sized cubes that satisfies the invisibility condition. Note that in both cases the view point in the figure is higher and further away than the viewing envelop and was chosen so that all the stones *would* be visible in the figure.

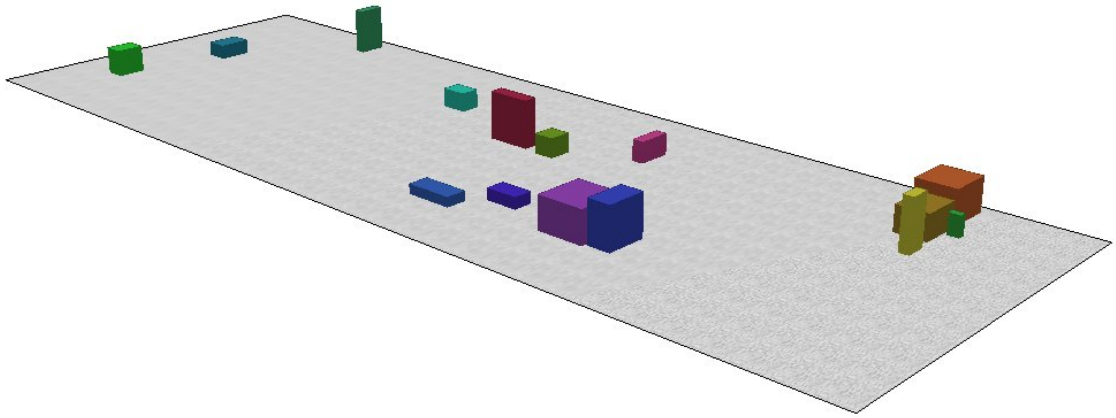

Figure 4. A synthetic “Zen Garden” with irregular blocks

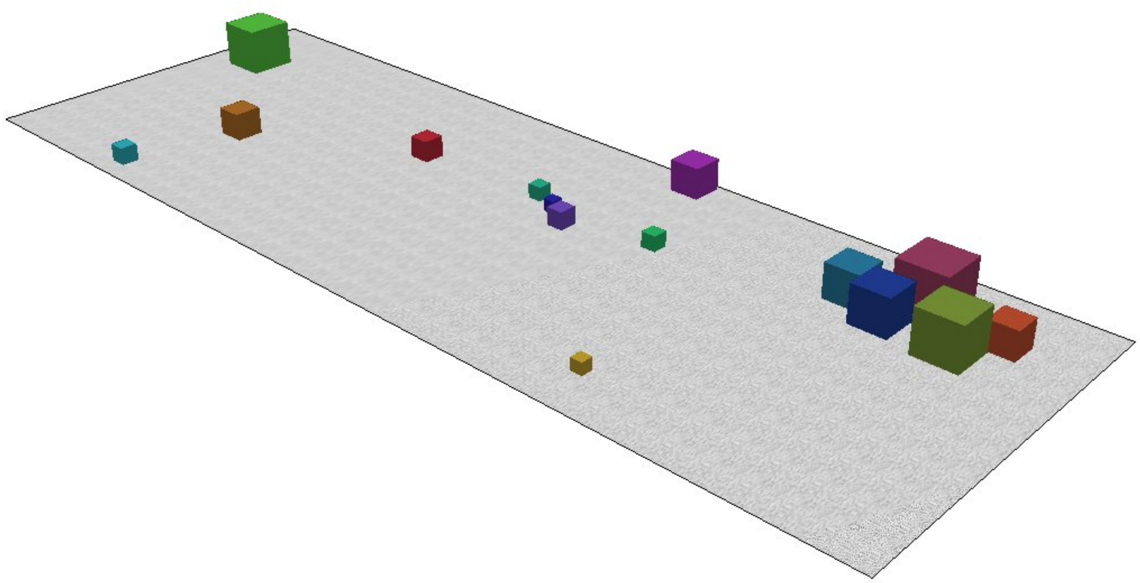

Figure 5. A synthetic “Zen garden” with irregularly sized cubes

4. Discussion

Although the methodology described above generates solutions that satisfy the invisibility constraints, it is a very laborious process (taking in the order of 1 to 3 days on a single processor Unix workstation). The majority of time is taken with estimating the fitness of a pattern as this involves calculating the visibility of all the objects at a sufficiently high level of precision (visual resolution). This means that from a computational concern the problem is “embarrassingly parallel” (Wilkinson & Allen 1999); allocating each view point to a processor in a cluster and the speed up is nearly linear. It is obvious that if real *karesansui* gardens do satisfy the visibility constraint that the designers must have used a better (and much more efficient) method.

The patterns generated by the algorithm are qualitatively dissimilar to real gardens; the synthetic patterns are rather more dispersed than in real gardens with many more "*Sute Ishi*." (thrown away stones) than in real gardens. The synthetic patterns always contain at least one cluster (group) and are never even remotely symmetric.

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5. References

Kuitert W. 2002. Themes, Scenes & Taste in the History of Japanese Garden Art. (revised ed) University of Hawaii Press.

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