

## Detailed description of Christopher Alexander's 15 fundamental properties.

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Alexander's 15 fundamental properties are essential to creating a sense of beauty and life in space and structures through geometrical and visual tools. An expanded description is necessary for anyone who wishes to program AI to discover the 15 properties in an image. They are given below in detail for use with large-language models. A reader should upload this list along with the image to be analyzed. These geometrical properties are part of a larger theory on design, which Alexander details in his 4-volume book *The Nature of Order* (Alexander, 2001, 2002); see also *Unified Architectural Theory* (Salingaros, 2013).

1. **Levels of Scale:** Successful designs incorporate different scales, from the dimension of the smallest detail up to the largest element, creating a sense of harmony. Each scale must be distinct, with scales in a hierarchy spaced closely enough in size (magnification) for scaling coherence, but not too close to blur the distinction between the next larger and smaller scales. Optimal magnification factors range between approximately 2 to 5. A subtle magnification factor of 1.5 is too close to distinguish one scale from another, whereas an abrupt jump in adjacent scales by a factor of 10 is disengaging. Baseboards, doors and door panels, ornament, structural elements, trim, windows and windowpanes, widths of borders and frames, define scales measured independently in the vertical and horizontal directions.
2. **Strong Centers:** Effective designs have multiple, strong, well-defined centers that draw attention and create internal focal points, like a central window or main entrance in a façade. Centers are nested within other centers, with symmetries creating a global focus from the surroundings towards each center of a region. One central, dominating, but empty form is not enough. Centers may be "defined", with something in the middle to focus attention, or "implied", where a complex engaging boundary focuses attention on its emptier interior. Many such mutually-reinforcing centers interconnect and overlap, rather than being isolated, creating an overall sense of balance.
3. **Thick Boundaries:** Clearly-defined boundaries help to strengthen centers and create a sense of enclosure and protection, for example, cornices, door surrounds, and window frames. Effective boundaries are proportionally wide to what they enclose; typically, the boundary measures roughly 1/3 of what it bounds. A thick boundary also functions as an "implied" center that is defined only through surrounding something else. A thick boundary's focusing role emphasizes the relationship between enclosed and enclosing elements. A thick or wide boundary arises as a smaller scale in the required scaling hierarchy.

4. **Alternating Repetition:** Alternating patterns break the monotony of translational symmetry by introducing rhythm and variation into repetition. This interplay of contrast and rhythm contributes to visual harmony and interest, such as in columns and window patterns. Differentiating each repeating component while maintaining overall coherence reinforces the larger scale. Meaningful alternation enriches designs, avoiding simplistic repetition that lacks informational depth (because the information is collapsible to no more than one repeating unit).
5. **Positive Space:** All spaces, both built and open, should feel complete and well-defined, contributing to the overall coherent design. The experienced space itself — either visual space on a structure, or pedestrian space where a user is situated — is typically convex, providing comfort and coherence, while the enclosing solid boundary is mostly concave. This principle applies equally to rooms (3-dimensional interior volume), urban spaces (2-dimensional area on plan), and the duality between figure and background. People strongly feel a threat from objects sticking out towards them, because those puncture the experienced positive space. A building's exterior is best used to define positive urban space, leaving no wasted regions.
6. **Good Shape:** Design elements should have good shapes that are coherent, self-contained, and contribute to the overall form. Harmonious and aesthetically pleasing forms remind us of animal shapes that must be compact for metabolism and locomotion. Compact shapes are cognitively “graspable” and arise when nested symmetries reduce the information overload. Every component of the overall structure must have good shape: it is not enough to have a clean and geometrically pure overall form. Perceivable objects produce a represented shape from many separate 2-D views, which the brain can then computationally manipulate in 3-D. Strange, disjointed shapes frustrate our cognitive mechanism.
7. **Local Symmetries:** Small-scale symmetries within the design contribute to its overall harmony. Bilateral symmetry about the vertical axis respects gravitational stability, which avoids nausea. Nested symmetries — where a smaller one fits inside a larger one — must act on every distinct scale in the scaling hierarchy down to the intricate details, and could be approximate. “Symmetry” does not mean overall symmetry on the largest scale, as is usually misunderstood. Positioning and subdividing features like doors and windows can work coherently with many different types of plane symmetries. A design or structure obeying fractal scaling will have increasingly more local symmetries as the pieces get smaller, creating a sense of order within complexity.
8. **Deep Interlock and Ambiguity:** Adjoining elements should interlock deeply, creating a sense of complexity and interconnectedness. Two regions can interpenetrate at a semi-permeable interface, which enables a transition from one region to another. A complex (not brusque) interface joins the two regions into a larger whole. Balconies and recessed windows in a building façade should interrelate visually to define a coherent overall 3-D geometry and avoid a fragmented impression. Abrupt, clean transitions between two regions coming up to each other weaken visual cohesion and therefore should be avoided.
9. **Contrast:** Effective use of contrast in color, form, shape, size, and texture can highlight differences and create interest while maintaining unity. Contrast operates across scales, from large forms, to defining many different scales going down in size. Differentiation and definition

of the smaller scales needs contrast to define the individual units, even as those units combine coherently on the large scale. Strongly contrasted regions can also be strongly connected; therefore, a building should not be detached from its surroundings. Contrast is needed to provide figure-ground symmetry of opposites. Thin window muntins contrast with transparent panes. Homogeneity and false transparency reduce contrast, weakening the design's overall coherence.

10. **Gradients:** Gradual changes and transitions in color, size, or texture help create a sense of continuity and flow. Gradients represent controlled transitions and avoid abrupt interruptions. Certain regions need continuous variation instead of contrast and interruption to help define global coherence. Sometimes we should not divide a form into discrete pieces but only change it gradually. Gradients provide a flowing method of getting away from uniformity in a way that feels adaptive and natural.

11. **Roughness:** A certain degree of imperfection and roughness can add authenticity and character to the design. Natural, irregular finishes can be appealing, and local symmetries can be broken and inexact when giving priority to achieving a larger coherence. Roughness here does not mean coarse-grained, but instead privileging adaptation and harmony over design precision and rigor. Adaptation to local conditions creates roughness, since it breaks regularity and perfect symmetry. A fractal structure goes all the way down in scales, so that nothing is smooth. Ornament can be interpreted as controlled "roughness" in repetition that avoids monotony through variety.

12. **Echoes:** Repeated motifs or themes throughout the design create a sense of coherence and unity. Similar visual patterns and shapes are repeated both on the same scale (translational and reflectional symmetries), as well as across different scales (fractal or scaling symmetry). Patterns and forms that "echo" one another tie separated elements together visually, enhancing coherence. Mathematical fractals are exactly self-similar, but natural fractals obey only approximate or statistical self-similarity, where one form "echoes" a larger or smaller form by means of common visual features.

13. **The Void:** Empty spaces, or voids, are essential to balance dense elements and create a sense of openness and freedom. Open spaces and regions complement and contrast with solid forms, which is necessary to avoid overfilling and cluttering the whole. An empty portion balances regions of intense detail, but two empty regions will not reinforce each other. A void is most effective when the adjoining complex structure surrounds and defines the void, not the other way around. In "implied" centers, a complex boundary focuses on the open middle — the void. It is not possible to fill in all of a fractal with detail, therefore its largest open component survives as the void.

14. **Simplicity and Inner Calm:** Simplicity in nature emerges from coherence and harmony, not reductionism. Designs should strive to create a sense of calm and tranquility by avoiding unnecessary complexity. A process of trimming irrelevant parts that do not contribute to a whole prevents elements that will detract from the overall coherence. The proper balance is achieved among all essential components through a lack of clutter. Symmetries are all cooperating intensely to support each other, with nothing extraneous or distracting. But an empty, minimalist design has no informational content and evokes a sense of disengagement and sterility.

15. **Not-Separateness:** Elements should feel deeply connected to each other and to their surroundings, fostering a sense of unity and wholeness. Unification is achieved via multiple geometric connections such as connecting pieces, similarities at a distance, and symmetries cooperating on different scales. An organic design, while highly complex in its details, feels balanced and coherent so that it is perceived as being blended seamlessly with no artificial breaks. Decomposition into simple constituent modules is neither obvious, nor possible. When every component is cooperating to give a coherent whole, nothing looks separate, and nothing draws attention to itself. Not-separateness goes beyond internal coherence, because the whole connects as much as possible to its environment.

### **References.**

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