A hexagonal coordinate system is simply a system which replaces the common square lattice upon which most images are mapped and described with a favour of a hexagonal lattice.

Why use a Hexagonal Coordinate System?

There are a number of reasons why hexagon-based descriptions of images are considered useful. One of the major advantages of hexagonal systems lies in the consistent connectivity of its constituent hexagons. In a common rectangular coordinate system, the distance between neighbouring points differs, depending on whether the neighbor is directly adjacent or diagonally adjacent (a total of 8 points, 4 at 1 unit distance, 4 at 2 unit distance). Under the hexagonal system, all points are equidistant, at 1 unit distance. This, along with the simple fact that hexagons are `rounded' rather than squares, tend to make the presence of edges in images such as curves more consistently under internal representations such as depth maps. As a result, an image converted from a square to a hexagonal coordinate system may yield an improvement in the representation of curves and edges. Moreover, for an image perceived as an array of individual pixels, and/or for an image converted from a square to a hexagonal coordinate system, the constituent points are more densely packed than an equivalent rectangular rendering of the image. This means that the space between the pixels is smaller, which in turn means that there is a higher density of pixels. It has been shown that mathematically, many operations of interest to the field of vision can be more easily executed on images that are laid out on a hexagonal lattice, including simulating the human eye's saccades [5] when focusing on aspects of an image.

Practicalities of Using a Hexagonal Coordinate System

There are generally four major considerations that must be pondered upon when using a hexagonal coordinate system (2):

• Image Conversion - Hardware capable of capturing images from the real world directly onto a hexagonal lattice is highly speculative, and so current methods of recording onto a grid that is not in the nature of a hexagonal coordinate system will have to extrapolate some pixel locations (which is generally less desirable than having all pixels provided directly from a source). The equivalent square lattices of the same apparent size, unless images are fed in at a deliberately higher resolution than is to be operated on, converted images shall have to extrapolate some pixel locations (which is generally less desirable than having all pixels provided directly from a source). Therefore, efficient means of converting a standard square-latticed image into a hexagonal one is in urgent need of processing into a hexagonal coordinate system. This is a challenge, but this is nothing of which the designers of this method at the University of Auckland on many of things referred to earlier in this article.

• Addressing and Storage - Any manipulations performed on images must be able to index and access individual pixels. In this case hexagons rather than squares, and any image in hexagonal form should be occlusive in hexagonal form (otherwise image conversion would have to be performed every time the image was accessed). Moreover, an indexing system that is simple to follow and makes the arithmetic of certain functions simpler would be very valuable.

• Image Display - Displays with actually obtaining the image in the first place, display devices in general do not use hexagonal lattices. Therefore the converted image must be remapped to a form that can be sent on to an output device (whether a printer, a display device, or any other). However, the display device operating in natural proportions and scales would need to be provided with a display with a hexagonal lattice. This means that the display of images in hexagonal form should be dependent on the indexing method used. This could be a simple reversal of the original conversion process, or be a more involved conversion.

Of these four considerations, the first two are examined in a little more depth below, the third requires a separate article for just about every operation described, and the fourth cannot be understood without going into specifics, except to say that it is the logical reverse of the first consideration.

Image Conversion

One method of converting from square lattice to hexagonal lattice is by image resampling. Hexagonal points are generated by mapping sampled points across an appropriate sampling grid. An conversion generally involves re-sampling the scale of the original cartesian coordinates. The hexagonal lattice is mapped onto a hexagonal coordinate system using the hexagon pixels. This method uses the pixel position of a point in the hexagonal lattice to determine the position of the corresponding square lattice point. The conversion process from square lattice to hexagonal lattice is dependant on the indexing method used. This could be a simple reversal of the original conversion process, or be a more complex conversion.

A layer-0 tile is defined by a single hexagon, L(L) in layer 0, with all of its surrounding neighbours. Layer L in a coordinate system is the layer above L which contains all of the tiles with which a hexagonal lattice was defined. To do this, the distance between squares in a hexagonal coordinate system is 1.5 times the distance between squares in a square coordinate system, and so in hexagonal form the tile of the layer below in the overarching super-tile, with 0 indicating the centre tile, and 1-6 the surrounding layer 1 tiles. This tile is equivalent to a layer 1 tile and the size surrounding layer 1 tiles. This 'tile' in layer 0 is defined by a single hexagon. A layer 1 tile is a hexagon and all 6 of its surrounding layer 0 tiles. The exact nature of this conversion is dependant on the indexing method used. This could be a simple reversal of the original conversion process, or be a more complex conversion.

Image Display

A hexagon coordinate system is simply a system which replaces the common square lattice upon which most images are mapped and described with a favor of a hexagonal lattice.

Issues with Hexagonal Coordinate Systems

There are some problems with hexagonal coordinate systems however. One issue that is very important is the fact that a hexagonal lattice is not used as a standard square lattice in the way that images are mapped to images. However, this is more of an issue with the use of the hexagonal lattice as a system default, with hexagonal systems merely a secondary choice.

One particularly interesting system is the layered system used in [1, 2, 3]. In all those papers, a layered system is developed, and the fourth cannot be elaborated on without going into specifics, except to say that it is the logical reverse of the first consideration.

References


Citations


Addressing and Storage

There are numerous ways to store and address a hexagonally represented image. A simple approach is to use a 3-element coordinate system, where the x and y axes are mapped to 0, 1, 2, 3, 4, 5, and 6 respectively, and where the z axis represents the distance between the layers (note that this is not the same z axis as in a standard coordinate system). In all those papers, a layered system is developed, and the fourth cannot be elaborated on without going into specifics, except to say that it is the logical reverse of the first consideration.

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There are many different methods, any of which can be used to solve this problem. For image resampling, but they are for the most part beyond the scope of this article. Some examples of the examples involved: basic sampling methods can be generalized for many forms of images. The fourth cannot be elaborated on without going into specifics, except to say that it is the logical reverse of the first consideration.

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