Geo-registration: (geo-coding, geo-referencing)


A frequent problem arises when images taken, at different times, by different sensors, or from different viewpoints need to be compared. In order to effectively identify the position between images, they must be registered, or properly aligned. Registration methods can be viewed as different combinations of the four components: a feature space, a search space, a search strategy, and a similarity metric. In order to correct the images, a number of transformations can occur. The most common of these include: translation, rigid body, rotation, and horizontal sheer. In order to find a correct registration, these operations must be performed in order to adequately compute the corrections to the data to offer a correlation between the image and some known registered object set.

One typical method for registration data with satellite imagery is to use a point-mapping technique with feedback. This method uses a selected number of points, and identifiable shapes to match the new image to these registered shapes. This in effect transforms the new image to map the registered data points. The new image is then considered to be geo-registered. Other methods which build off of this initial registration type includes an elastic-based model, which uses the registered points and then applies a distortion as if an elastic material was being used to transform the image. One of the earliest techniques was called the “rubber-mask” technique.


Geo-registration is an important part of mapping geo-spatial data. There is an increasing amount of methods for collecting such data, however, a continuing technical problem involves determining how to relate the geographic locations of objects on the real world. Geo-registration can be identified in a number of ways. At a coarse level, geo-spatial registration can be derived by the camera telemetry data and digital terrain map data [page 1]. Higher precision is achieved by registering observed objects within frames to stored reference imagery. Geo-spatial registration is the mapping between camera coordinates and ground coordinates, and depends on the location, orientation of the camera, and the distance and topography of the ground. Geo-registered data is based on geo-coordinates that have been created and stored. Typically these coordinates require a unique feature that is easily identifiable in an image.
Smoothing:


Many methods have been proposed for smoothing Maximum Entropy models. One standard way is to eliminate low frequency features, based on the assumption that they are unreliable or uninformative.


Typically images will suffer from distortions which lead to problems of recovering the underlying structure of the image. It is important to be able to uncover the underlying structure of the image as, typically the discontinuities in the image, may be the most interesting part of the image. In order to minimize the loss of such data, smoothing is done in order to reduce the distortions of the image as well as preserve any discontinuities that exist. Many different methods exist to smooth the images, this paper primarily focuses on using a estimating a regression function at each point in order to smooth the regression equations.


From Chapter 5:

Smoothing methods attempt to find functional relationships between different measurements. In smoothing, unlike standard regression, the data points are allowed to determine the form of the fitted curve, rather than highly structuring them. Some basic smoothing techniques include Kernel Smoothing, which uses a weighted average of the observations within the smoothing window, Local Regression, which uses a low degree polynomial in the neighborhood to gain a local linear approximation. The regression coefficients are chosen to minimize the functions variation from the previous point. Penalized Least Squares (Smoothing Splines) uses the least squares criterion. This method is typically used with a single predictor variable. Regression Splines may result in a jagged appearance, since the derivatives are discontinuous. More commonly used are cubic splines with the basis functions having two continuous derivatives. Last, the Orthogonal series represents the data with respect to a series of orthogonal basis functions (sines and cosines). This retains only the low frequency terms.


One of the most prevalent uses of image processing is for smoothing or denoising images. This is typically done with a low-pass filter, which reduces noise, but also blurs sharp features and details such as edges. This article talks about many non-linear techniques which reduce noise while preserving edges. Using a non-linear technique is important in large scale images due to the nature of needing to preserve sharp features, such as in a topological map. While much of this article is not relevant to GIS, it gives a background of what can be done with any image to reduce noise but preserve distinct features of an image.
A gyroscope is a device that is used to measure or maintain a particular orientation. The device is based on the principle of conservation of angular momentum. The device itself is a spinning wheel on an axis. The spinning wheel tends to resist change due to its momentum. In order to measure the movement and force, a series of gimbals or Gyro Frames are used to detect the change in direction of an object compared to the resistance of change from the spinning wheel. Early gyroscopes were used in compasses which used an electric motor to maintain the momentum of the flywheel given the inherent friction within the system.

Gyroscopes have been used in a number of settings, such as guidance systems for missiles, compasses, and assisting with stability in satellites and other sensory devices. Gyroscopes used in these satellites allow for self-correction to provide a relatively stable path, as well as providing a means to deal with excessive rotation.

There have been a number of variants on the original gyroscope, such as the ring-laser gyroscope, the fiber-optic gyroscope, and the vibrating-structure gyroscope. These different types of gyroscopes perform better in specific applications, but all of these types of systems utilize the same basic principle to detect spin and orientation.

The concepts of gyroscopes primarily came out after Einsteins theory of General Relativity. After this time, there was a general interest to be able to measure relative measurements. The gyroscope was designed to be able to utilize the concepts within the Theory of General Relativity to be able to make these measurements. However, early attempts at the gyroscope, in particular large gyroscopes did not become effective, due to the lack of technology until after world war 2, during the cold war era. The article summarizes the needs for satellites in order to provide accurate guidance to look at particular instances. This is accomplished with the assistance of the Gyroscope, which must allow a sensor to be directed towards anything from a star to a particular location on the earth. The article also discusses the need for fine tuning the instrumentation to less than 1 arc-sec / yr, in order to make accurate relativistic measurements.

The article also talks about the key conditions in order to make the near-zero effect at which the gyroscope cannot detect movement. This paper describes this amount as $10^{-11}$ deg / yr. This is a near-zero that most experimental gyroscopes must meet. In addition, other near zeros need to be the torque needed to maintain the spinning of the gyroscope, and the third component is the reaction torque that is needed to initially start the spinning of the gyroscope. These three parts need to be dealt with in order to make an accurate gyroscope.