are not described here, as Tikhonov regularization is well-known in the art.

A key quantity used to construct the RPI matrix is the regularization parameter which controls the image restoration. Larger parameter values protect the restored image from the corrupting effects of the optical system but result in a restored image which has lower resolution. An optimum or near optimum value for the regularization parameter may be derived automatically from the image data. Singular value decomposition (SVD) of the imaging operator matrix may be used to compute the RPI matrix. By estimating the noise or error level of the degraded image the singular values of the matrix determine the extent to which the full information in the original scene may be recovered. Note that the use of the SVD process is not essential in determining the RPI matrix, and other methods such as QR decomposition of the imaging matrix may also be used to achieve essentially the same result.

The imaging matrix size increases approximately as the square of the image size, and the computational burden associated with forming the RPI of the imaging matrix quickly becomes intolerable. However, in the special case that the image and object fields are the same size and are sampled at the same intervals (as is the case here), the imaging matrix can be expanded into circulant form by inserting appropriately positioned, additional columns. A fundamental theorem of matrix algebra is that the Fourier transform diagonalizes a circulant matrix. This allows the reduction of the image reconstruction algorithm to a pair of one dimensional fast Fourier transforms, followed by a vector—vector multiplication, and finally an inverse one dimensional fast Fourier transform. This procedure allows the image restoration by this Tikhonov regularization technique to be done entirely in the Fourier transform domain, dramatically reducing the time required to compute the reconstructed image. FIG. **19** provides an illustration of the steps taken to obtain the reconstructed image using the linear transform method.

A flow diagram of the Linear Algebra Technique according to the present invention is shown in FIG. **19**. Referring now to FIG. **19**, the technique first converts the imaging data collected by the optical system of the sensor into a matrix of the form $g_I(i, j)=\Sigma_m\Sigma_n h(I-m, j-n)f(m, n)+n_1(i, j)$, where h is a matrix representation of the point spread function of the optical system and f is the matrix representation of the unblurred background with the embedded object, while n_1 is the matrix representation of the additive white noise associated with the imaging system (module **12**). Next, imaging data g_2 comprising the image scene data which contains only the background data is obtained in the form of $g_2(i, j)-\Sigma_m\Sigma_n h\ (I-m,\ j-n)b(m,n)+n_2\ (i,j)$ where b is a matrix representation of the unblurred background data taken alone and n_2 is a matrix representation of additive system white noise (module **14**). Both g_1 and g_2 are then low-pass filtered to the cut-off frequency of the optical system to reduce the effects of noise (module **15**). Module **16** then shows the subtraction step whereby the matrix representation (g_3) of the difference between blurred scene data containing the background and object of interest (g_1) and the blurred scene containing only the background data (g_2) is formed as (g_1−g_2). Next, the position and size of the object of interest is specified by choosing x,y coordinates associated with image matrix (g_1−g_2) (module **18**). A segment of sufficient size to contain the blurred object in its entirety is then extracted from the matrix representation of (g_1−g_2), as shown in Module **20**. That is, an area equal to the true extent of the local object plus its diffracted energy is determined An identically located segment (i.e. segment having the same x,y coordinates) is extracted from the blurred background scene matrix g_2 as shown in module **22**. The two image segments output from module **15** and **20** are then input to module **24** to restore g_2 and (g_1−g_2) using nth order Tikhonov regularization. The restored segments are then added together as shown in step **26** and the area containing the restored object of interest is extracted therefrom, as shown in module **28**.

The resulting reconstructed image includes much of the spatial resolution which was lost due to diffraction blurring effects.

It should be noted that the present invention is not limited to any one type of optical sensor device. The principles which have been described herein apply to many types of applications which include, but are not limited to, Optical Earth Resource Observation Systems (both Air and Spaceborne), Optical Weather Sensors (both Air and Spaceborne), Terrain Mapping Sensors (both Air and Spaceborne), Surveillance Sensors (both Air and Spaceborne), Optical Phenomenology Systems (both Air and Spaceborne), Imaging Systems that utilize optical fibers such as Medical Probes, Commercial Optical Systems such as Television Cameras, Telescopes utilized for astronomy and Optical Systems utilized for Police and Rescue Work.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the spirit and scope of the present invention.

What is claimed is:

1. In an optical system having a detector means and processor means in which imaging data is obtained comprising noisy blurred scene data containing an object to be reconstructed, and noisy blurred background data of the same scene, a method for increasing the spatial resolution of the imaging data produced by the optical system for providing an image of higher resolution, comprising the steps of:

converting the imaging data into a first matrix;

regularizing the first matrix by performing nth order Tikhonov regularization to the first matrix to provide a regularized pseudo-inverse (RPI) matrix; and

applying the RPI matrix to the first matrix to provide a reconstructed image of the object.

2. The method of claim **1** wherein the optical system is diffraction limited.

3. The method according to claim **1**, wherein the RPI matrix is determined via a singular value decomposition (SVD) of the first matrix obtained from the point spread function of the optical system.

4. The method according to claim **1**, wherein the RPI matrix is determined using QR decomposition of the first matrix.

5. A method for substantially increasing the spatial resolution of imaging data produced by an optical system, comprising the steps of:

converting the imaging data into a first matrix g_1, comprising background data and object of interest data, and a second matrix g_2 comprising background data;

subtracting the second matrix g_2 from the first matrix g_1 to obtain a third matrix g_3 indicative of the difference between the first and second matrices,

specifying a position and size of an object of interest in the third matrix g_3;

extracting from the third matrix g_3 a segment having coordinates which completely include a blurred version of the object of interest;