

levels of a valid monetary banknote to determine the texture sections. Other embodiments may use different texture values, such as contrast levels, halftone levels, and edge frequencies. The exact type of texture value utilized is in fact intermediate, as long as the texture decision map **520** suffices in identifying texture sections **530** from the image sections having texture values within a valid range according to a valid monetary banknote.

#### Object Determination

Having both a banknote boundary map **420** and texture decision map **520** in place, object determination can be resolved. The goal of object determination is to distinguish a number of objects within the scanned image, any of which can potentially be a monetary banknote. In order to accomplish this, overlapping regions in the texture decision map must have individual objects separated from each other. This is accomplished by removing texture sections in the texture decision map that correspond to the border sections in the banknote boundary map. Because the border sections in the banknote boundary map outline the banknotes, it can be used to separate individual banknote regions in the texture decision map.

FIGS. **6** and **7** illustrate the object determination **140** step. In FIG. **6** a texture decision map **610** is shown having texture sections of three overlapping banknotes. The banknote boundary map **620** contains the border sections outlining the three banknotes. When the texture sections corresponding to the border sections are removed, the three banknotes are then separated in object separation **630**. FIG. **7** illustrates a similar example, but with the texture decision map **710** containing two banknote regions having surrounding background noise. In this case, as the texture sections for the two banknote areas are already separated, object determination **140** manages to remove the redundant noise to more properly define the banknote regions. Texture sections in the texture decision map **710** that correspond to border sections in the banknote boundary map **720** are removed, with the results shown in object separation **730**. True banknote areas and residual objects remain, all of which will be verified in the following step for correspondence with valid monetary banknotes.

#### Texture Property Value Determination

Having identified and isolated a number of objects in object determination **140**, texture property value determination **150** focuses on calculation of a texture property value for each of the individual objects. This texture property value will then be compared to known values corresponding to valid monetary banknotes to verify whether the texture of the relevant object agrees with the valid monetary banknote.

The exact calculation for the texture property value can vary according to the different embodiments of the present invention. For example, in one embodiment, it is calculated according to a texture feature map, which possesses a texture feature value for each image section of the scanned image. The texture feature map therefore already contains texture characteristics of the scanned image. Texture feature values for the image sections that correspond to the object in question are used in calculation of the texture property value of the object.

In one embodiment, the texture feature map is a gray level feature map having gray levels as the texture feature value for each section. In other embodiments, the texture feature map is a contrast feature map having contrast values as the texture feature value for each section, or even halftone feature map having halftone values as the texture feature value for each section. The exact type or format of the texture feature map and corresponding texture feature value for image sections is intermediate, as long as the texture feature map suffices in

characterizing image sections of the scanned image in terms of texture. The principles taught in the present invention are equally applicable for any type of texture map which may be implemented.

With a texture feature map selected, the texture property value can then be determined. One preferred embodiment jointly utilizes a mean value and a variance value of the texture feature values for image sections corresponding to the object in calculation of the texture property value. However, other embodiments may singularly use a mean value, or just a variance value in calculation of the texture property value. Again, the exact calculation or formulae pertaining to the texture property value can vary, and is intermediate, as long as an appropriate texture feature map is utilized that characterizes image sections of the scanned image in terms of texture. The principles taught in the present invention are equally applicable regardless of the precise calculation and implementation of the texture property value.

In order to provide a further degree of resolution in calculating the texture property value, an additional embodiment of the present invention utilizes a second texture feature map having a second texture feature value for each image section in the texture property value calculation. The use of two texture feature maps reduces variability in the calculation, as now it utilizes two distinct texture feature aspects relating to the scanned image. Also, a greater accuracy in verification of texture sections corresponding to valid monetary currency is assumed.

Similar to the first texture feature map, the second texture feature map can be a gray level feature map having gray levels as the second texture feature value for each section, a contrast feature map having contrast values as the second texture feature value for each section, or a halftone feature map having halftone values as the second texture feature value for each section. Again, the exact type or format of the second texture feature map and corresponding second texture feature value is intermediate, as the teachings of the present invention are equally applicable for any type of second texture map implemented.

#### Shape Property Value Determination

Shape property value determination **160** focuses on calculating a shape property value for each of the identified objects. The shape property value will then be compared to known values corresponding to valid monetary banknotes to verify whether the shape of the relevant object agrees with that of the valid monetary banknote.

The specific formulae for calculating the shape property value can vary according to a number of embodiments. In one embodiment, the shape property value for each object simply comprises determining an area of the object. This may include utilizing four corners of the object to determine the area of the object. Other embodiments can additionally include: determining a distance between center points of two different diagonal lines within the object, determining lengths of two parallel lines within the object, determining an inner product using four angles within the object, and determining a ratio of a width of the object and a height of the object.

Although the exact calculation of the shape property value can vary according to different embodiments, its exact representation is intermediate, as the teachings of the present invention are equally applicable for any calculation for shape property value implemented.

#### Object Removal

With texture property values and shape property values determined for each object, the object removal **170** focuses on removing objects that do not correspond to a valid monetary banknote. This is accomplished by further removing texture