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Multispectral imagery over clear water provides information about the seafloor, in shallow coastal waters up to 20m, which can be used to model depth, bottom type and seafloor texture. Glint, or specular reflection off the sea surface, is often present, thus masking the effect of bottom reflectance on algorithms which model the seafloor. Glint can be effectively removed in cases where the water is very clear due to the high correlation of glinted surfaces over multiple bandwidths. This information used in conjunction with differences in attenuation between the visible and infrared portions of the electromagnetic spectrum were used by Lyzenga [1] to derive a method for glint removal. The technique presented here expounds on that method by adding a texture technique to break out bright areas, such as white sandy shoals, that sometimes alias as glint, but have different texture, and by adding a quadratic term to the correction model.

## BACKGROUND

Light in the range from  $350-575\mu$  has a transmittance rate greater than 90% through the water column in pure sea water [2]. In the near infrared region, between  $750-775\mu$ , the transmittance rate falls off to below 10%. Since there is little or no penetration in the near infrared, the commonality between the visible and near-infrared bands is restricted to the surface. Glint, being strictly a surface feature, generates a high degree of correlation between the visible and near IR bands. In the absence of glint, there is very little correlation. Only in the case where the water is highly laden with particulates such as sediment, algae, etc., is the correlation high in the absence of glint. The technique requires relatively clear water, and a correlation,  $r \ge .90$ , to be effective. In cases where the water is not clear, most of the signal in the few upper centimeters of the water column is corrected out.

The method discussed here is a variation of Lyzenga's method, with the inclusion of a squared term in the model. The glint correction for the visible-band i based on the IR-band j takes the form:

$$\Delta Y_{i} = \alpha (Y_{j} - \bar{Y}_{j}) + \beta (Y_{j}^{2} - \bar{Y}_{j}^{2})$$

The corrected visible-band signal is given by

$$\hat{\mathbf{Y}}_{i} = \mathbf{Y}_{i} - \mathbf{\Delta}\mathbf{Y}_{i}$$

where:

= Raw signal for visible band,

= Raw signal for near-IR hand,

= Mean IR signal, non-glint deep water.

= Mean IR signal squared, non-glint deep water, and

 $\alpha,\beta$  = Regression coefficients.

Application of this model requires the identification of suitable non-glint deep water regions over which the averages  $\tilde{Y}_j$  and  $\tilde{Y}_j^2$  are computed. To compute the regression coefficients, each of the visible bands are regressed against the near IR band. The region where the coefficients are computed requires a deep water region containing both glint and non-glint.

## RESULTS

The glint correction, used in conjunction with a texture mapping algorithm, allow for differentiation and correction of glinted areas of the sea surface with minimal correction of non-glint features. The algorithm has been successfully used on data collected with the NOARL multispectral scanner over shallow water areas in the Florida Keys and near Panama City, Fla. Results derived using imagery over waters around Horn Island, off the cost of Biloxi, Ms. were not as good as those in the clearer waters around Florida, emphasizing the limitations of the algorithm to clear coastal waters. Cases where Codes shoals were slightly beneath the water line and had high d/or reflectances similar to glint were cleared up by using a 1 texture analysis of the neighborhood surrounding the highly reflective water pixels.



- D.R. Lyzenga, "Shallow-water bathymetry using combined lidar and passive multispectral scanner data," *Remote Sensing*, vol. 6:1, pp. 115-125, 1985.
- [2] Jerlov, N.G., Optical Oceanography, New

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