

# Additional Notes and Solution Manual For: Matrix Computations: Third Edition by Gene H. Golub and Charles F. Van Loan

John L. Weatherwax\*

February 9, 2007

## Chapter 2 (Matrix Analysis):

### Basic Ideas from Linear Algebra

#### P 2.1.1 (existence of a $p$ rank factorization of $A$ )

Assume  $A$  is  $m \times n$  and of rank  $r$ . The using elementary elimination matrices we can reduce  $A$  to its row reduced echelon form  $R$ , given by  $E_1 A = R$  or  $A = E_1^{-1} R = E_2 R$ . In this reduction  $E_2$  is  $m \times m$  and  $R$  is  $m \times n$ . Because  $R$  has  $n - r$  zero rows we can block decompose it as follows

$$R = \begin{bmatrix} \hat{R}_{r \times n} \\ 0_{m-r \times n} \end{bmatrix}$$

where we have listed the dimensions of the the block matrices next to them. Now  $\hat{R}$  is of rank  $r$ . In addition, block decomposing  $E_2$  as

$$E_2 = \begin{bmatrix} \hat{E}_{m \times r} & \hat{E}_{m \times m-r} \end{bmatrix}.$$

Now since  $E_2$  is of rank  $m$  the first  $r$  columns of  $E_2$  is a matrix of rank  $r$ . This block decomposition gives for  $A$  the expression

$$A = \begin{bmatrix} \hat{E} & \hat{E} \end{bmatrix} \begin{bmatrix} \hat{R} \\ 0 \end{bmatrix} = \hat{E} \hat{R}$$

This gives the decomposition of  $A$  into  $\hat{E}$  of size  $m \times r$  and  $\hat{R}$  of size  $r \times n$  each of rank  $r$ , thus proving the decomposition.

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# Golub And Van Loan Solution Manual

**Michael Hoelscher**



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