Assignment 12

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The link to the solution is

https://github.com/Adarsh1310/EE5609

Abstract—**This documents solves a problem based on Row Echelon form.**

1 Problem

Suppose $\mathbf{R}$ and $\mathbf{R}'$ are 2×3 row-reduced echelon matrices and that the system $\mathbf{RX}$=0 and $\mathbf{R}'\mathbf{X}$=0 have exactly the same solutions. Prove that $\mathbf{R}$=$\mathbf{R}'$.

2 Solution

Since $\mathbf{R}$ and $\mathbf{R}'$ are 2×3 row-reduced echelon matrices they can be of following three types:-

1) Suppose matrix $\mathbf{R}$ has one non-zero row then $\mathbf{RX}$=0 will have two free variables.Since $R'\mathbf{X}$=0 will have the exact same solution as $\mathbf{RX}$=0, $R'\mathbf{X}$=0 will also have two free variables. Thus $\mathbf{R}'$ have one non zero row.Now let's consider a matrix $\mathbf{A}$ with the first row as the non-zero row $\mathbf{R}$ and second row as the second row of $\mathbf{R}'$.

$$\mathbf{R} = \begin{pmatrix} 1 & a & b \\ 0 & 0 & 0 \end{pmatrix} \tag{2.0.1}$$

$$\mathbf{R}' = \begin{pmatrix} 1 & c & d \\ 0 & 0 & 0 \end{pmatrix} \tag{2.0.2}$$

$$\mathbf{A} = \begin{pmatrix} 1 & a & b \\ 1 & c & d \end{pmatrix} \tag{2.0.3}$$

Any $\mathbf{X}$ satisfying $\mathbf{RX}$=0 and $R'\mathbf{X}$=0 will also satisfy $\mathbf{AX}$=0 and thus, $\mathbf{A}$ in it's reduced form must have one non-zero row which is possible only when the rows of $\mathbf{A}$ are equal because leading entries in both the vectors equals one.Thus,$\mathbf{R} = \mathbf{R}'$.

2) Let $\mathbf{R}$ and $\mathbf{R}'$ have all rows as non zero. Let $\mathbf{R}$=$\begin{pmatrix} 1 & a & b \\ 0 & 1 & c \end{pmatrix}$ and $\mathbf{R}'$=$\begin{pmatrix} 1 & d & e \\ 0 & 1 & f \end{pmatrix}$.Now let's consider another matrix $\mathbf{A}$ whose first two rows are from $\mathbf{R}$ and last two rows are from $\mathbf{R}'$.

$$\mathbf{A} = \begin{pmatrix} 1 & a & b \\ 0 & 1 & c \\ 1 & d & e \\ 0 & 1 & f \end{pmatrix} \tag{2.0.4}$$

Any value of $\mathbf{X}$ satisfying $\mathbf{RX}$=0 and $\mathbf{R}'\mathbf{X}$=0 will also satisfy $\mathbf{AX}$=0. Therefore row reduced echelon form of $\mathbf{A}$ must have two non-zero rows, which implies the rows of $\mathbf{R}$ and $\mathbf{R}'$ must be a linear combination of each other. It is possible only when the leading coefficients of the first row of $\mathbf{R}$ and $\mathbf{R}'$ occur in the same column.By similar argument, the leading coefficients of the second rows must also occur in the same column. Thus,the only way the rows of $\mathbf{R}$ and $\mathbf{R}'$ are linear combination of one another is that the respective rows coincide and hence $\mathbf{R} = \mathbf{R}'$.

3) Suppose matrix $\mathbf{R}$ have all the rows as zero then $\mathbf{RX}$=0 will be satisfied for all values of $\mathbf{X}$. We know that $\mathbf{R}'\mathbf{X}$=0 will have the exact same solution as $\mathbf{RX}$=0 then we can say that for all values of $\mathbf{X}$=0 equation $\mathbf{R}'\mathbf{X}$=0 will be satisfied hence, $\mathbf{R}'$=$\mathbf{R}$=0.