3. Solve by elimination

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Solve by elimination

We start with an example that can be solved with the method of "elimination."

Example 3.1 Let $A = \begin{pmatrix} -1 & 1 \\ 1 & 3 \end{pmatrix}$. We will use $\vec{b} = \begin{pmatrix} 1 \\ 7 \end{pmatrix}$.

Goal: solve for $\vec{x}$ in $A\vec{x} = \begin{pmatrix} 1 \\ 7 \end{pmatrix}$.

Let's break this problem down. There are two unknowns, x_1 and x_2:

$$\vec{x} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}. \tag{5.55}$$

We also have two equations, which result from doing the matrix multiplication:

$$A\vec{x} = \begin{pmatrix} 1 \\ 7 \end{pmatrix} \quad \text{equivalent to} \quad \begin{pmatrix} -x_1 + x_2 \\ x_1 + 3x_2 \end{pmatrix} = \begin{pmatrix} 1 \\ 7 \end{pmatrix} \tag{5.56}$$

Thus we need to solve the linear system:

$$\begin{aligned} (1)\colon -x_1 + x_2 &= 1 \\ (2)\colon x_1 + 3x_2 &= 7 \end{aligned}$$

One common method is to "solve by elimination."

Solve by Elimination

The idea behind elimination is to successively replace the equations in a linear system by simpler equations without losing any information. In this example, we can add equation (1) to equation (2) to obtain

$$(1)+(2)\colon 4x_2 \quad = 8 \tag{5.57}$$

From this equation, we see $x_2 = 2$. Substituting $x_2 = 2$ in equation (1) we obtain

$$-x_1 + 2 = 1 \tag{5.58}$$

Therefore, $x_1 = 1$. In conclusion,

$$\vec{x} = \begin{pmatrix} 1 \\ 2 \end{pmatrix} \quad \text{solves} \quad \begin{pmatrix} -1 & 1 \\ 1 & 3 \end{pmatrix} \vec{x} = \begin{pmatrix} 1 \\ 7 \end{pmatrix} \tag{5.59}$$

In general, the method of elimination may involve further steps, such as multiplying an equation by a constant before adding it to the other equation. In summary: **To solve for $\vec{x}$ in $A\vec{x} = \vec{b}$, we can use elimination.**

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