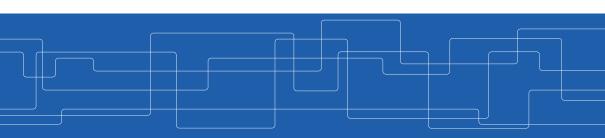


# Principal Component analysis

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## Decomposition of a matrix

From linear algebra, we know that we can multiply two vectors into a

$$\text{matrix. } \mathbf{X} = \mathbf{u} \otimes \mathbf{v} = \mathbf{u} \mathbf{v}^{\mathsf{T}} = \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix} \begin{bmatrix} v_1 & v_2 & v_3 \end{bmatrix} = \begin{bmatrix} u_1 v_1 & u_1 v_2 & u_1 v_3 \\ u_2 v_1 & u_2 v_2 & u_2 v_3 \\ u_3 v_1 & u_3 v_2 & u_3 v_3 \\ u_4 v_1 & u_4 v_2 & u_4 v_3 \end{bmatrix}.$$



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▶ What if we could do the opposite? I.e. given a matrix  $\mathbf{X}$ , what would be the vectors  $\mathbf{u}$  and  $\mathbf{v}$  that closest represents  $\mathbf{X}$  so that  $\mathbf{X} \approx \mathbf{u}\mathbf{v}^T$ . This is in essence, what you do with principal component analysis (PCA).

► See notebook



#### More principal components to your PCA

Once you remove the principal components from a matrix  $\mathbf{X}$  the remaining residues,i.e.  $\mathbf{X} - \mathbf{u}^{(1)}\mathbf{v}^{(1)\mathsf{T}}$  might in its turn be decomposed into vectors. I.e. we can calculate the vectors  $\mathbf{u}^{(2)}$  and  $\mathbf{v}^{(2)}$  that best describe the matrix  $\mathbf{X} - \mathbf{u}^{(1)}\mathbf{v}^{(1)\mathsf{T}}$ . We call these the second principal components, and the first are called first principal components.



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- ▶ In this manner we can derive as many principal components as there are rows or columns (which ever is the lowest number) in X. In most applications, we settle for two such components.



		Sample					Eigen Sample	
		1	2	3		M	$u^{(1)}$	$u^{(2)}$
Gene	1	X <sub>11</sub>	$X_{12}$	X <sub>13</sub>		$X_{1M}$	$u_1^{(1)}$	$u_1^{(2)}$
	2	$X_{21}$	$X_{22}$	$X_{23}$		$X_{2M}$	$u_2^{(1)}$	$u_2^{(2)}$
	3	X <sub>31</sub>	$X_{32}$	$X_{33}$		$X_{3M}$	$u_3^{\overline{(1)}}$	$u_3^{(2)}$
	:	:	:	:	٠.		:	:
	Ν	$X_{N1}$	$X_{N2}$	$X_{N3}$		$X_{NM}$	$u_{N}^{(1)}$	$u_N^{(2)}$
Eigen Gene	$\mathbf{v}^{T(1)}$ $\mathbf{v}^{T(2}$	$v_1^{(1)} \\ v_1^{(2)}$	$v_2^{(1)} \\ v_2^{(2)}$	$v_3^{(1)} \\ v_3^{(2)}$		$v_M^{(1)}$	$S_1$	C
	V'(2	$V_1^{(-)}$	$V_2^{(-)}$	$V_3^{(-)}$		$v_M^{(2)}$		$S_2$



# Thanks!