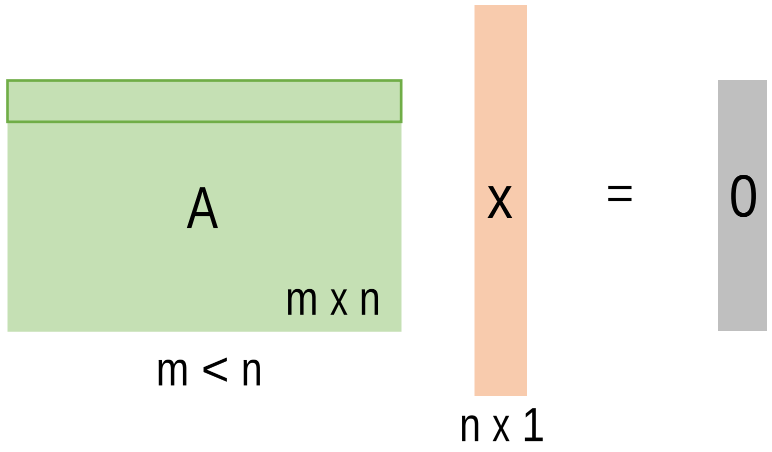
# Nullspace

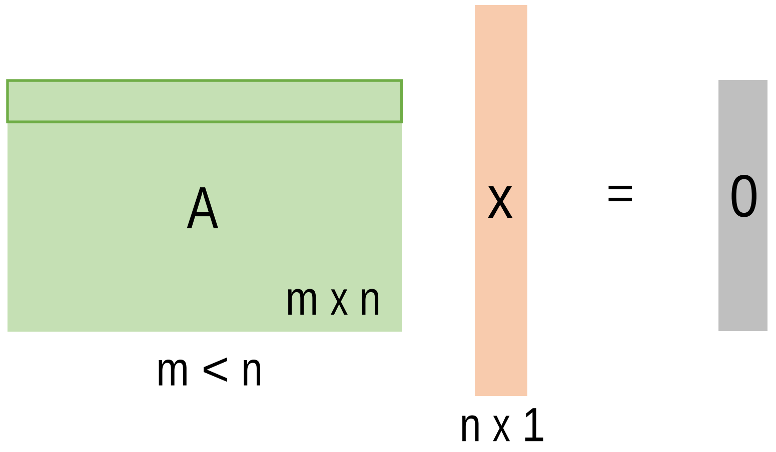
# eqs < # unknowns



# Nullspace

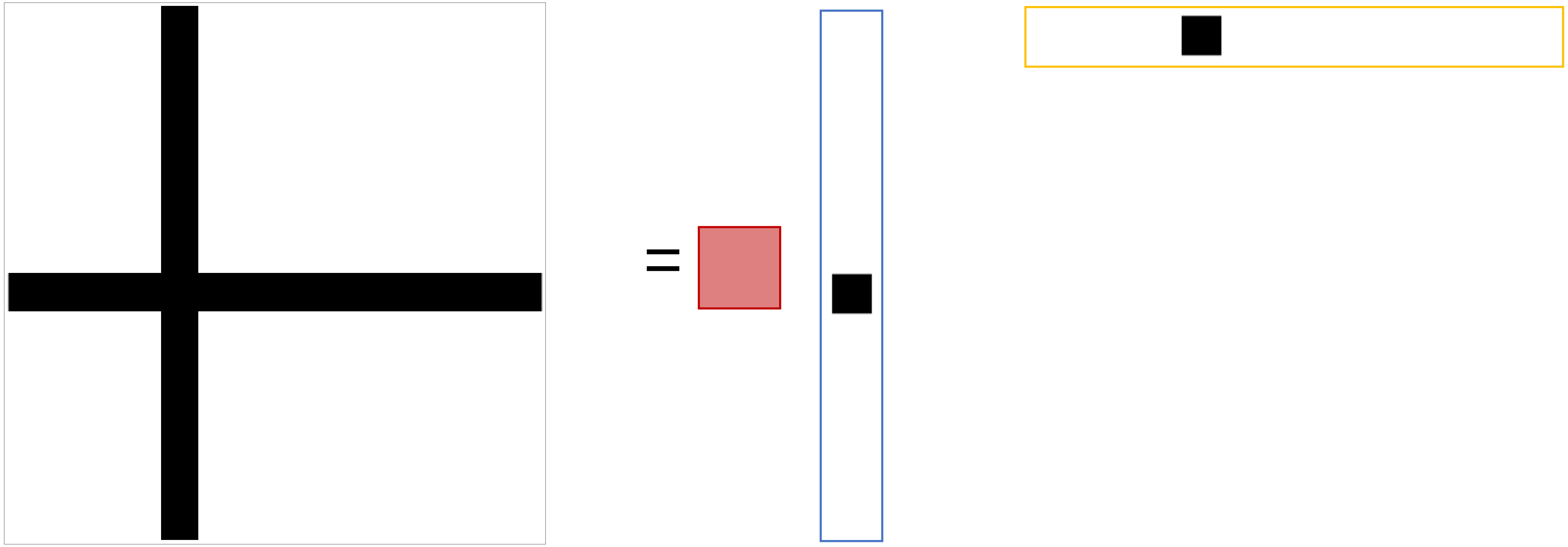
# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.



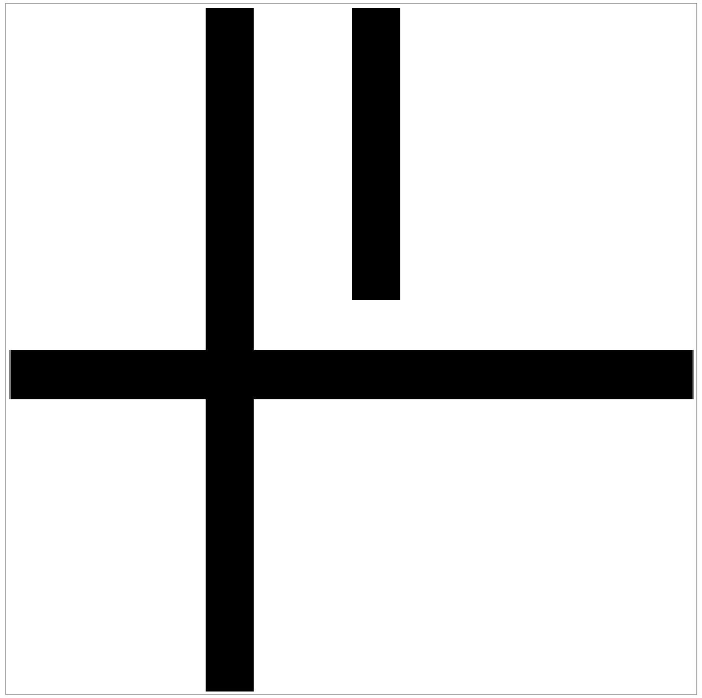

$$\longrightarrow \quad x = \text{null}(A)$$

# More SVD



14x14

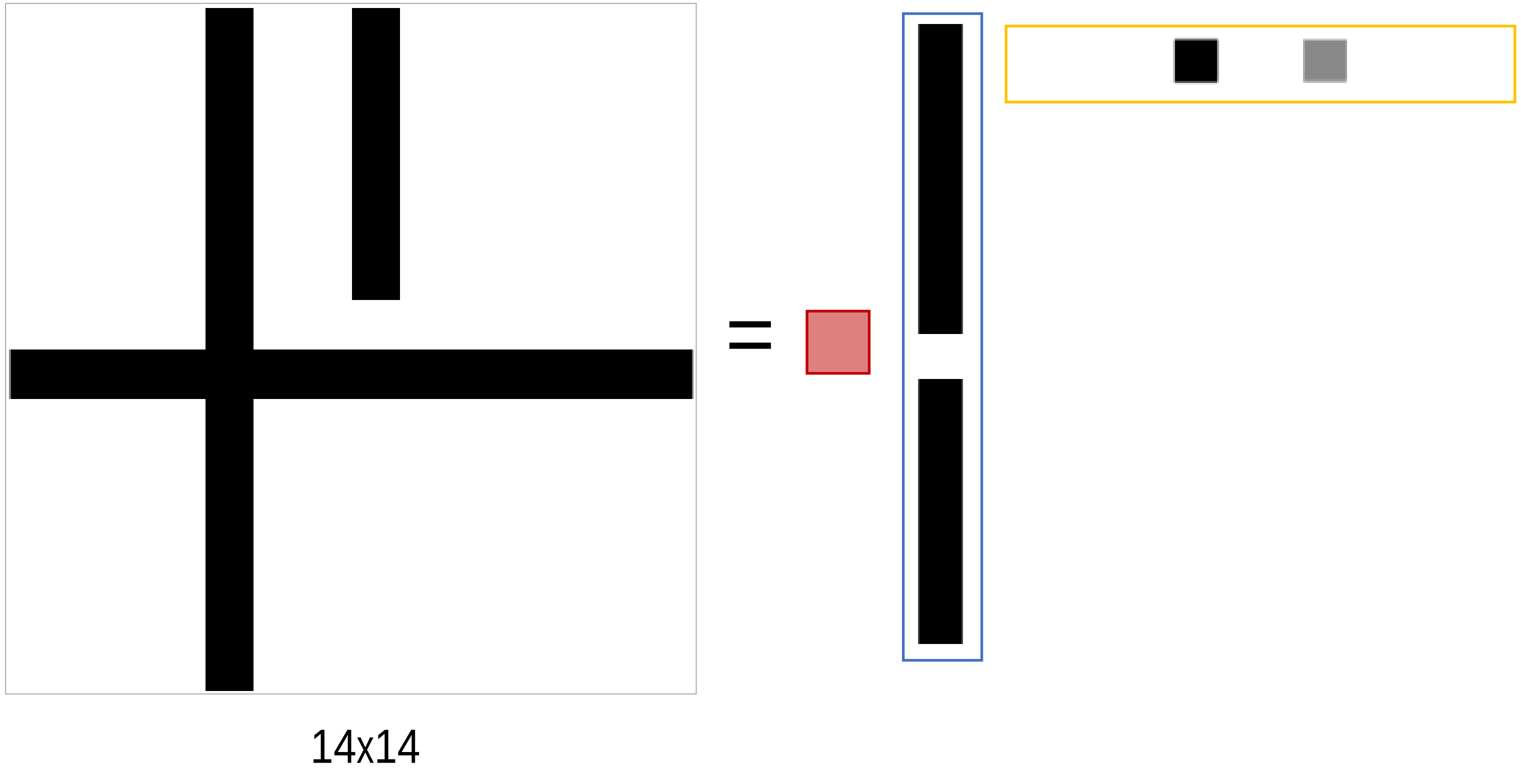
# More SVD



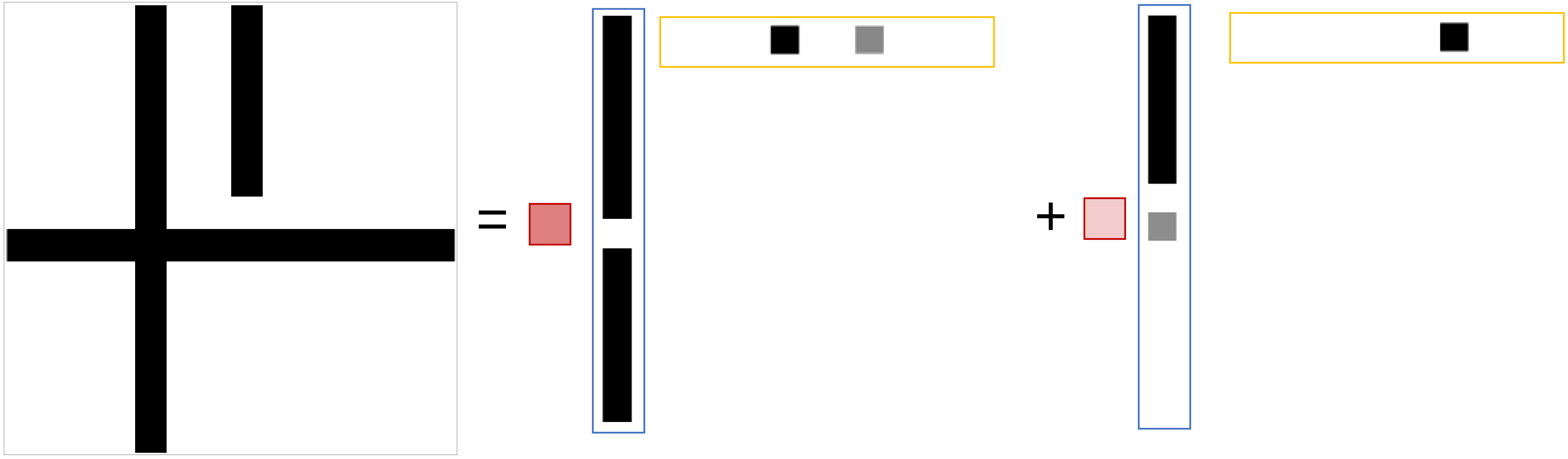
=

14x14

# More SVD

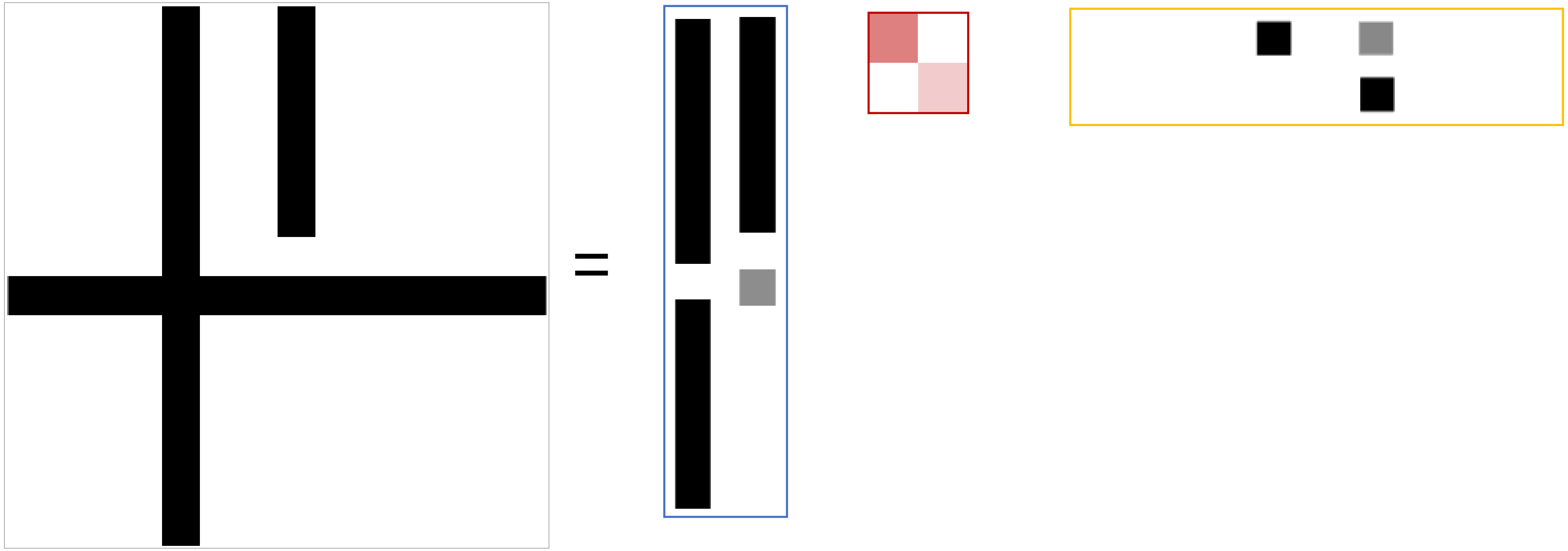


# More SVD



14x14

# More SVD

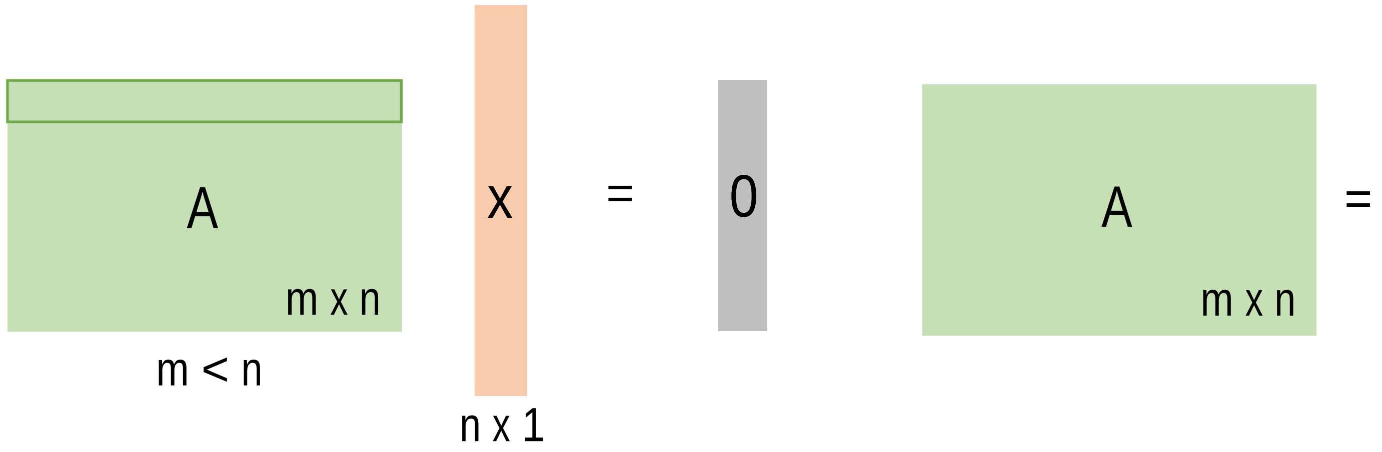



14x14

# Singular Value Decomposition (SVD)

# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.

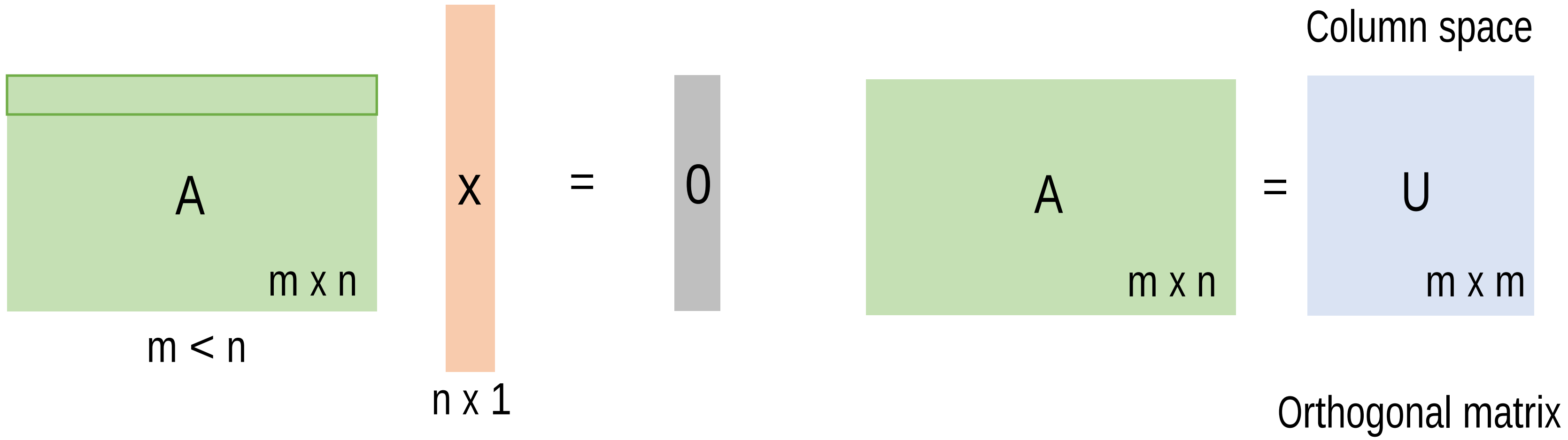



$$\longrightarrow \; x = \text{null}(A)$$

# Singular Value Decomposition (SVD)

# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.

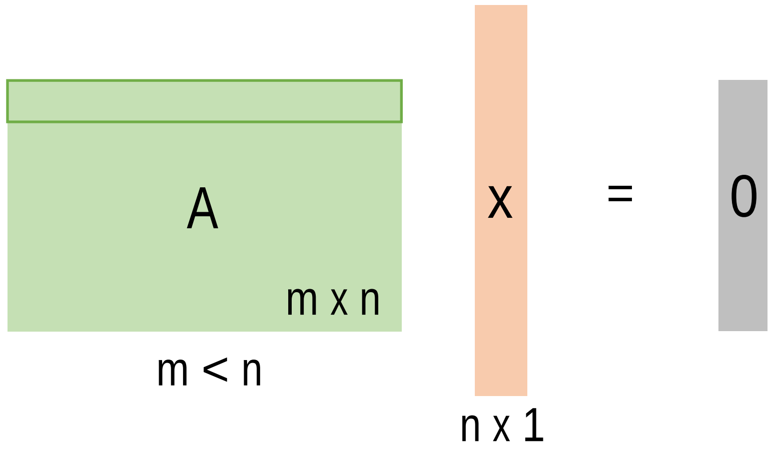


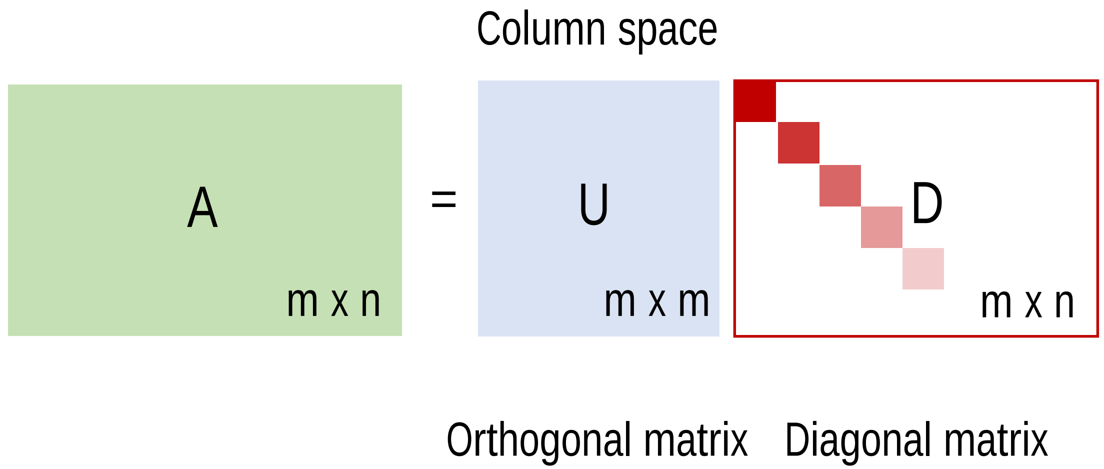

$\longrightarrow x = \mathrm{null}(A)$

# Singular Value Decomposition (SVD)

# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.



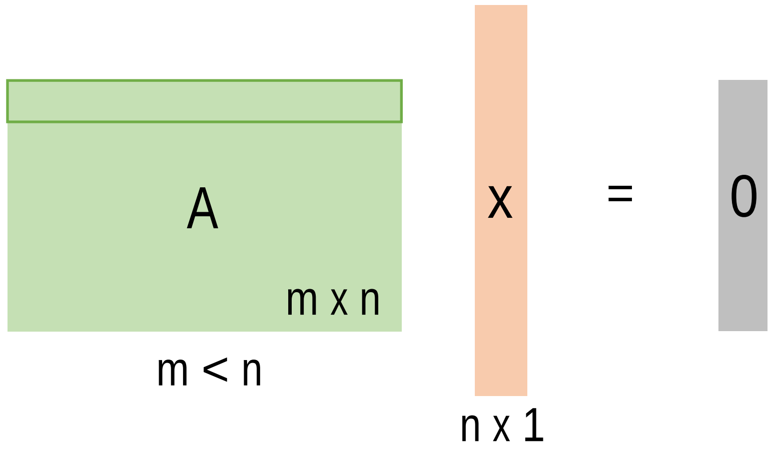



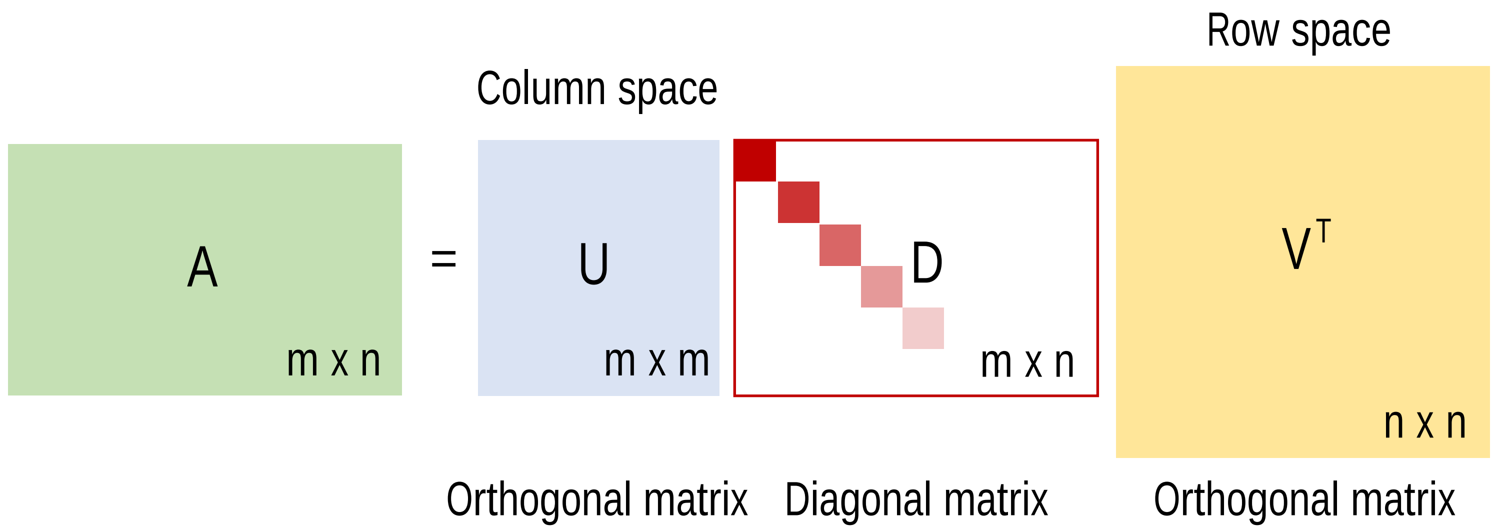

$\longrightarrow x = \text{null}(A)$

# Singular Value Decomposition (SVD)

# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.



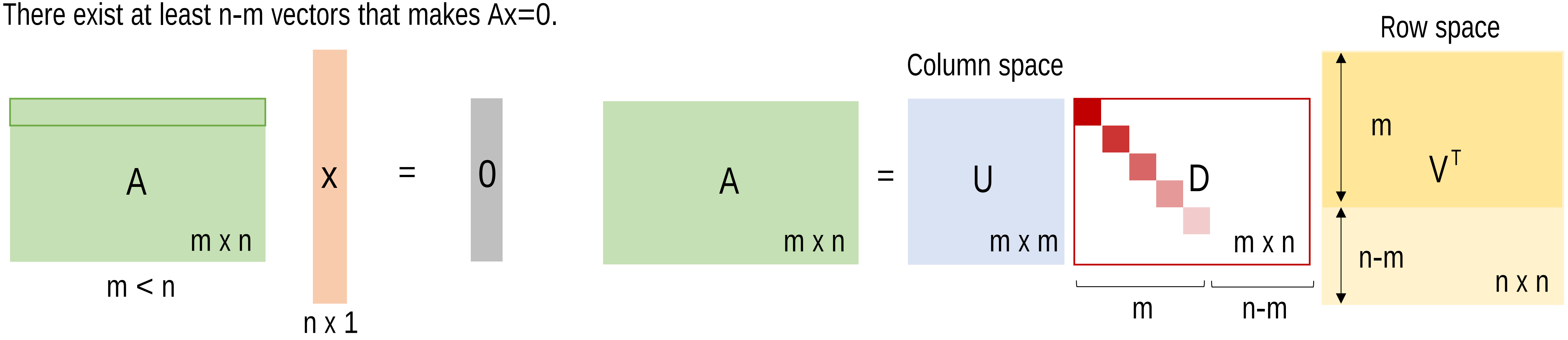




$\longrightarrow \; x = \text{null}(A)$

# Singular Value Decomposition (SVD)

# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.

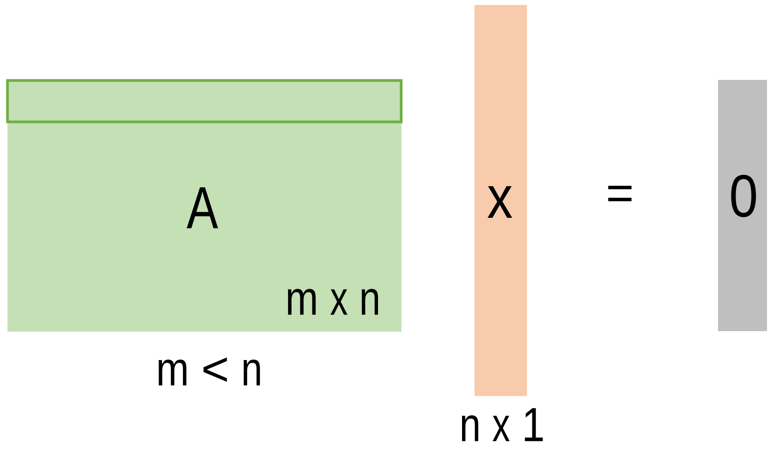


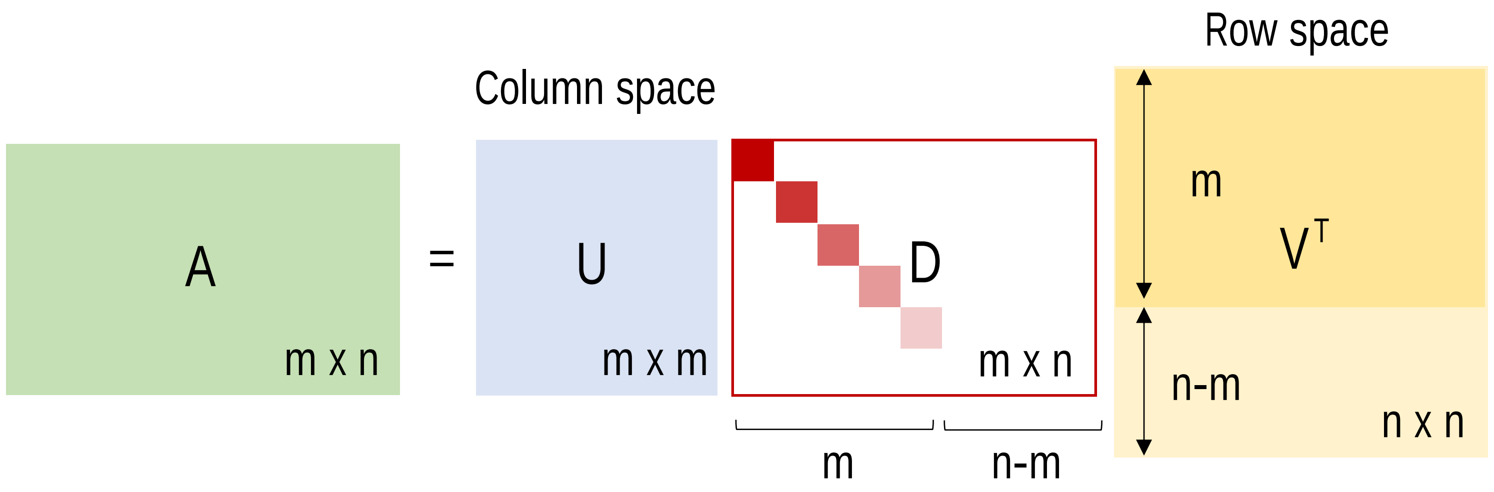

$\longrightarrow x = \text{null}(A)$

# Singular Value Decomposition (SVD)

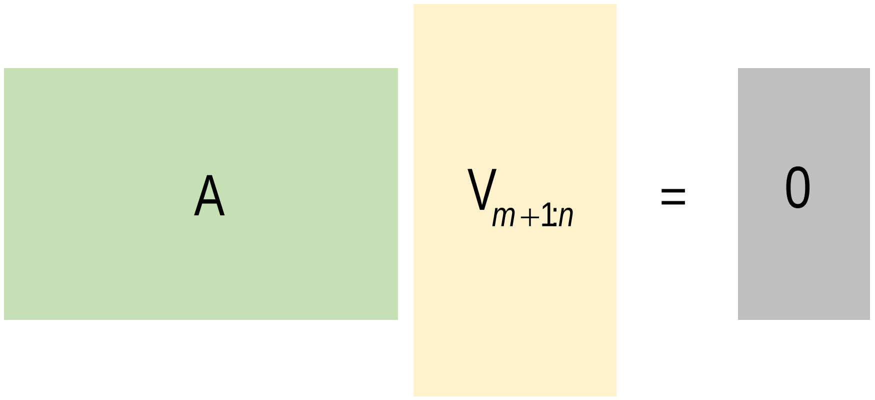
# eqs < # unknowns

There exist at least n-m vectors that makes Ax=0.




$\longrightarrow x = \mathrm{null}(A)$

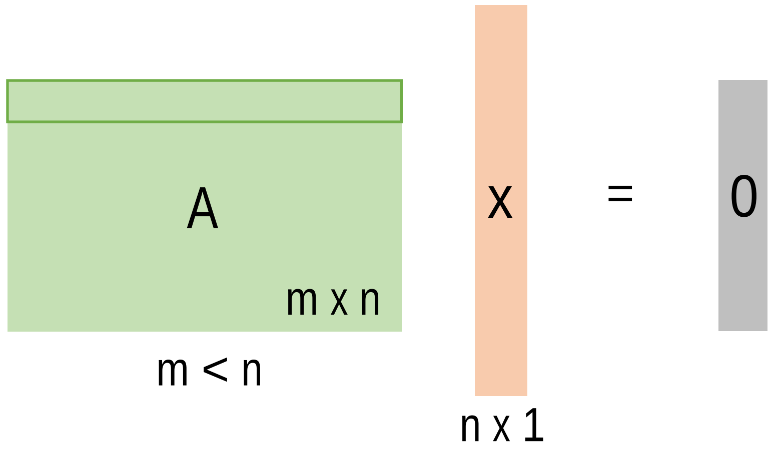


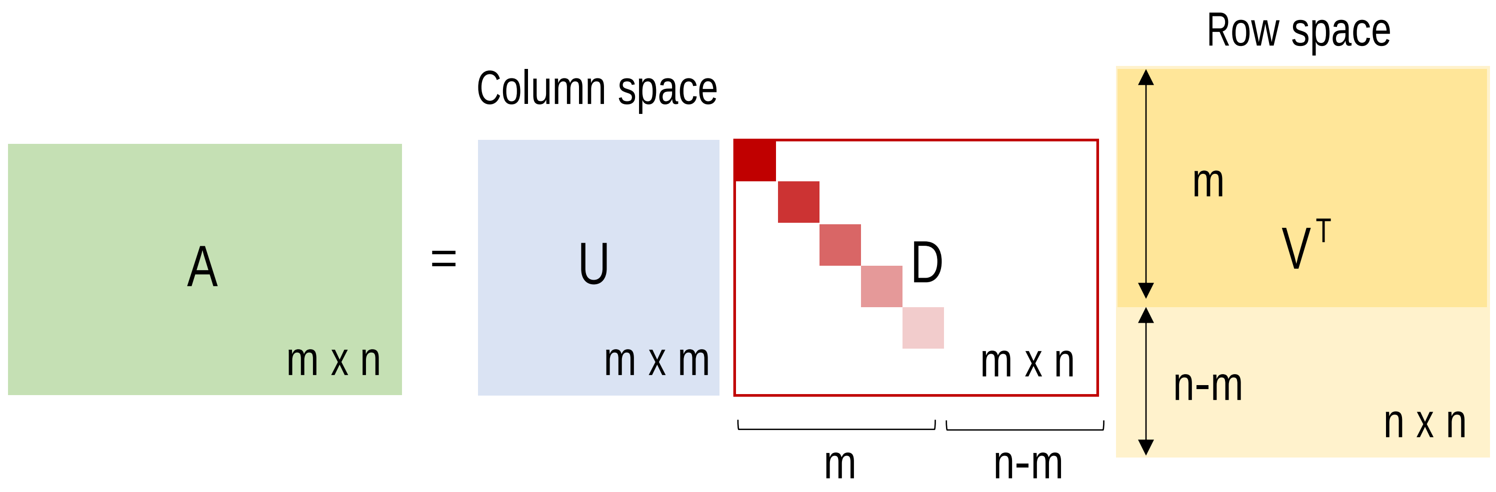

$$V_{m+1:n} = \mathrm{null}(A)$$

# Singular Value Decomposition (SVD)

\# eqs < # unknowns

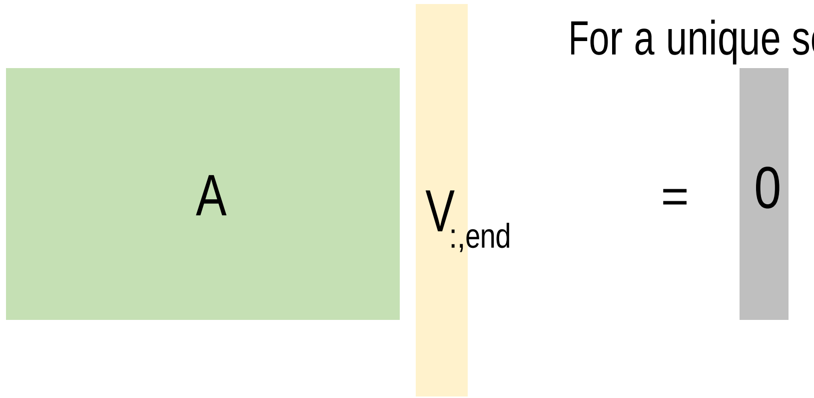
There exist at least n-m vectors that makes Ax=0.




$\longrightarrow\; x = \text{null}(A)$

For a unique solution, A should be m x (m+1)

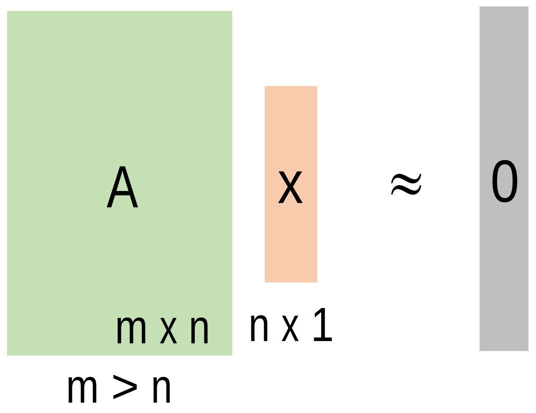


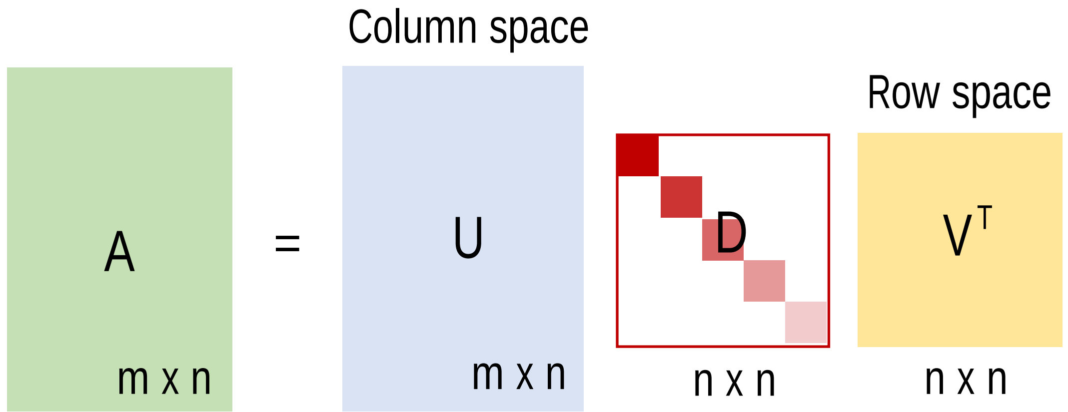

$$V_{:end} = \text{null}(A)$$

# Singular Value Decomposition (SVD)

# eqs > # unknowns

There exist no nullspace of A.



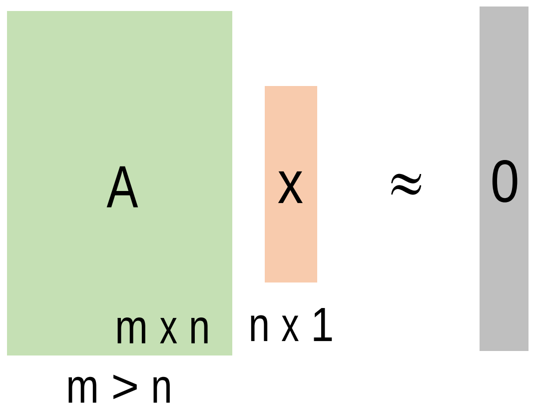



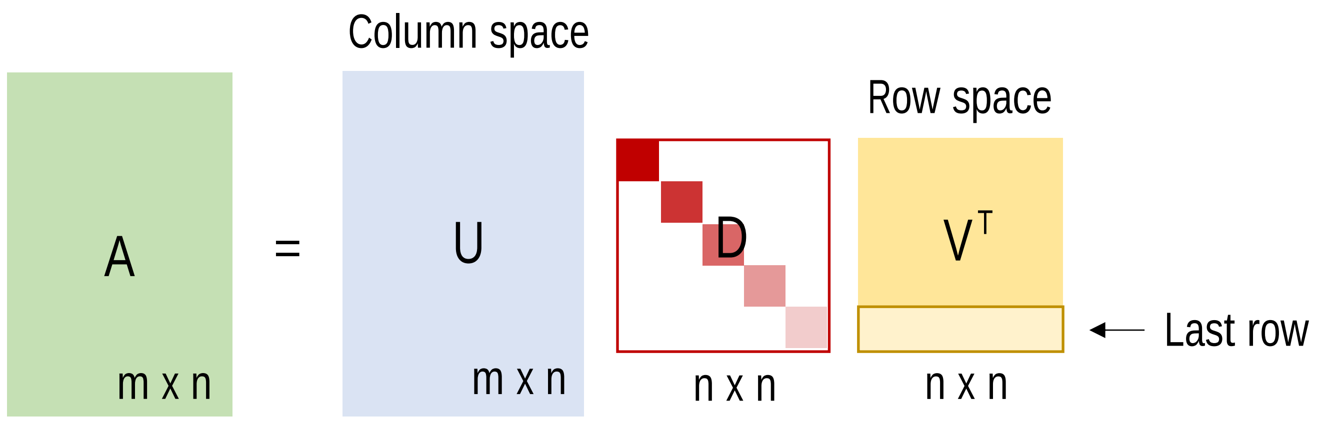

$$\underset{x}{\text{minimize}} \|Ax\|^2 \text{ subject to } \|x\| = 1$$

# Singular Value Decomposition (SVD)

\# eqs > # unknowns

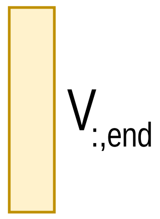
There exist no nullspace of A.



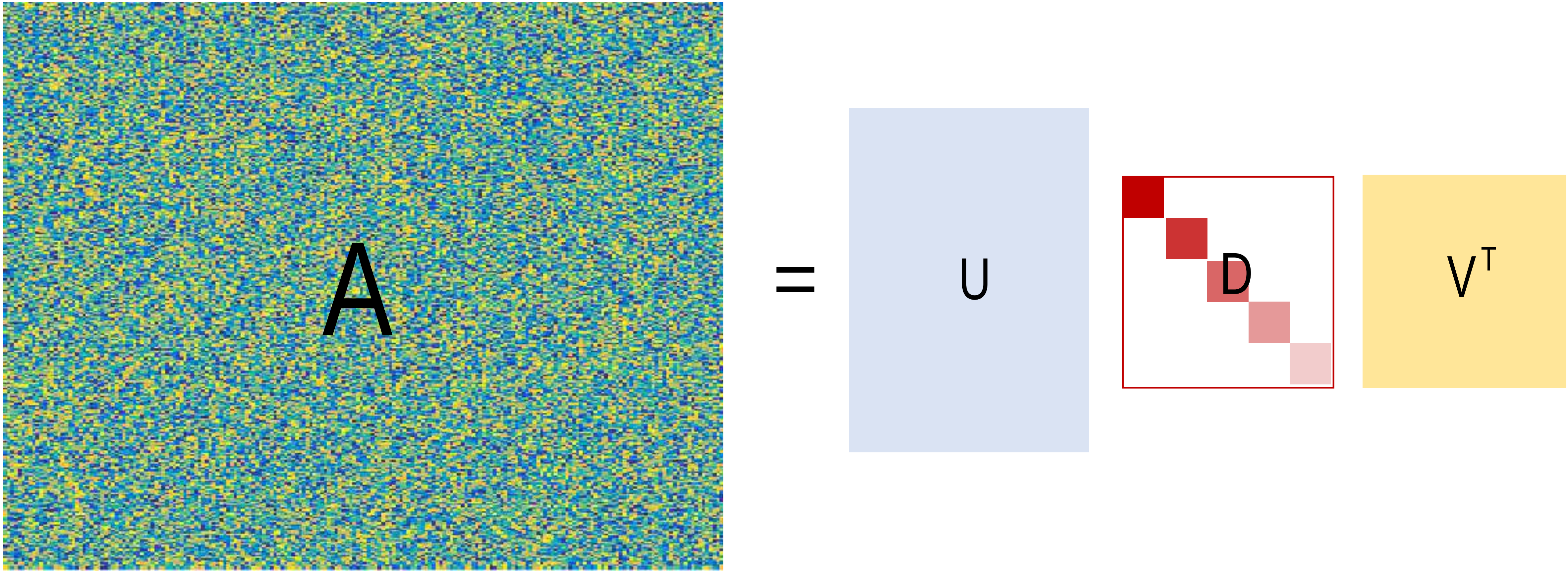




$$\underset{x}{\text{minimize}} \|Ax\|^2 \text{ subject to } \|x\| = 1$$

Approximated nullspace of A:

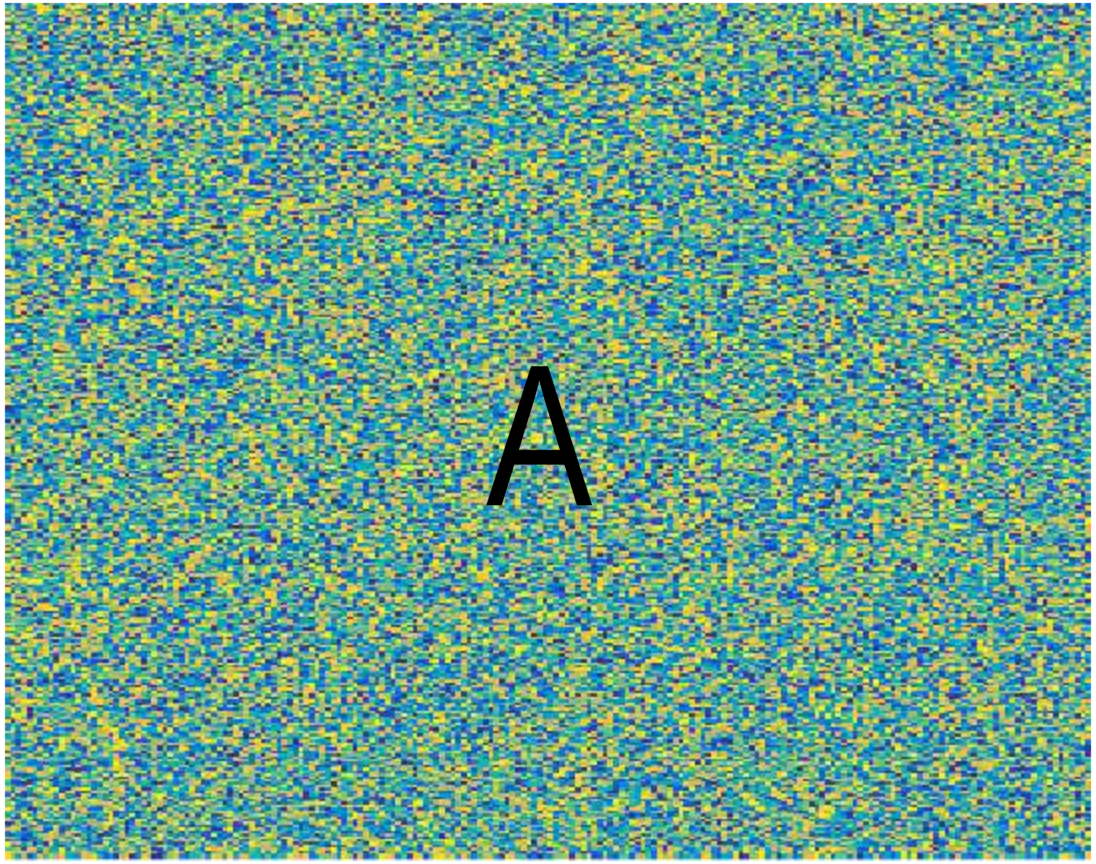


# Random Matrix SVD




Random matrix

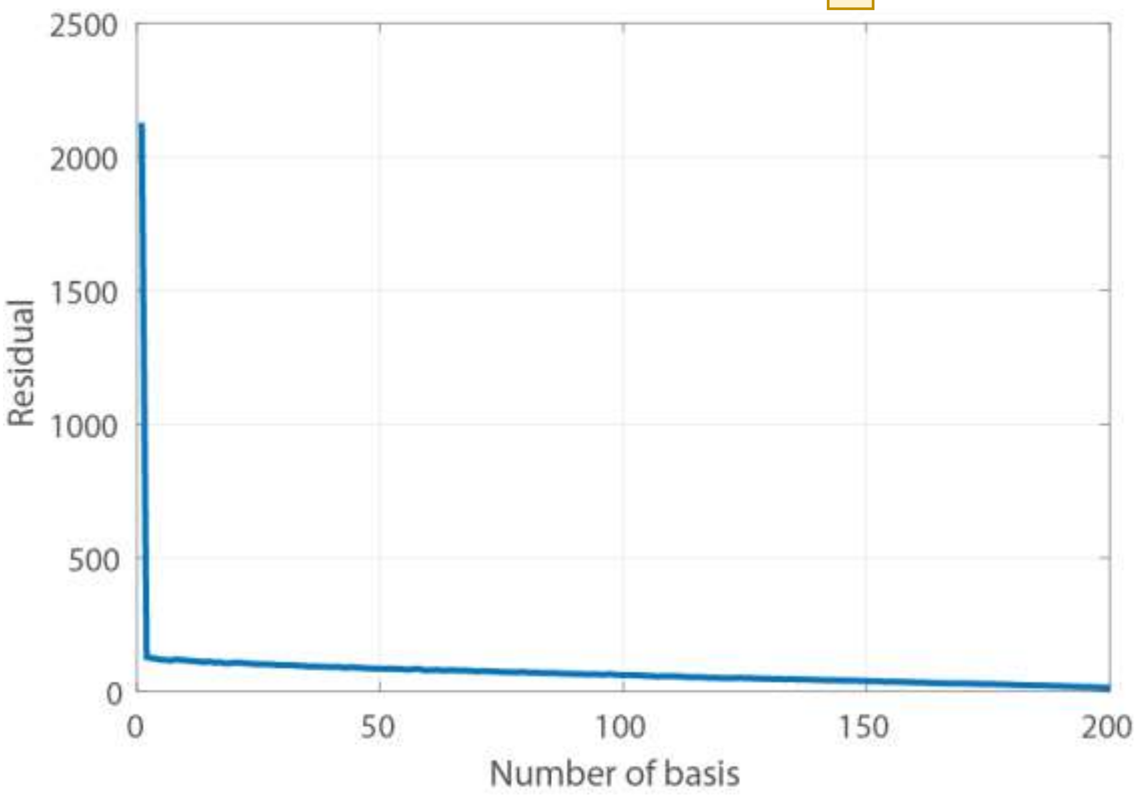
# Residual (Nullspace Approximation)



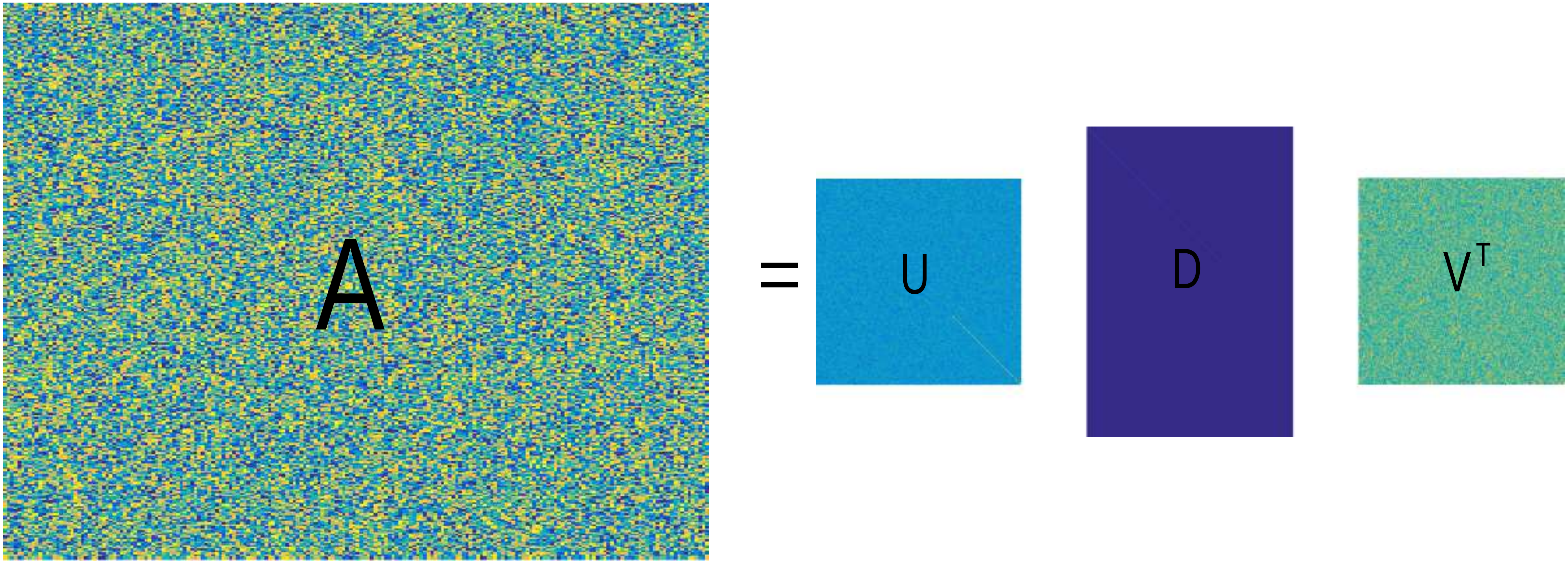

Random matrix

$V_{:,i}$

Approximated nullspace of A: $V_{:,end}$

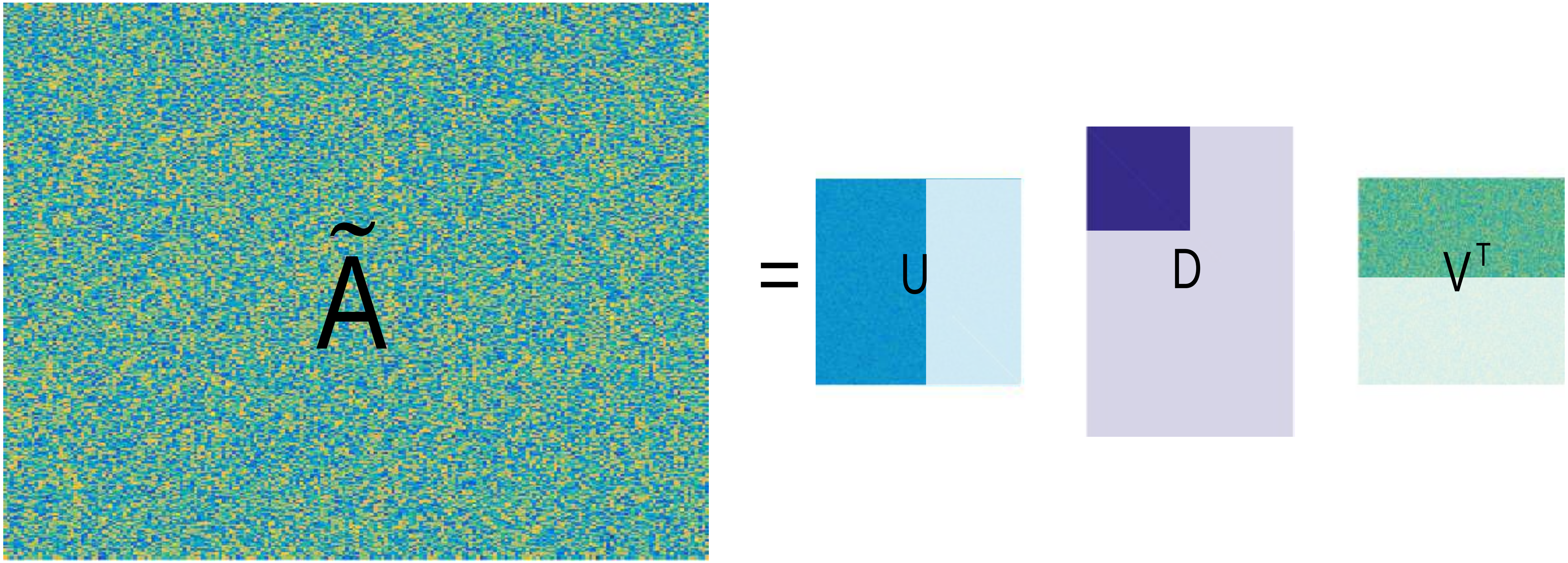


# SVD Matrix Approximation



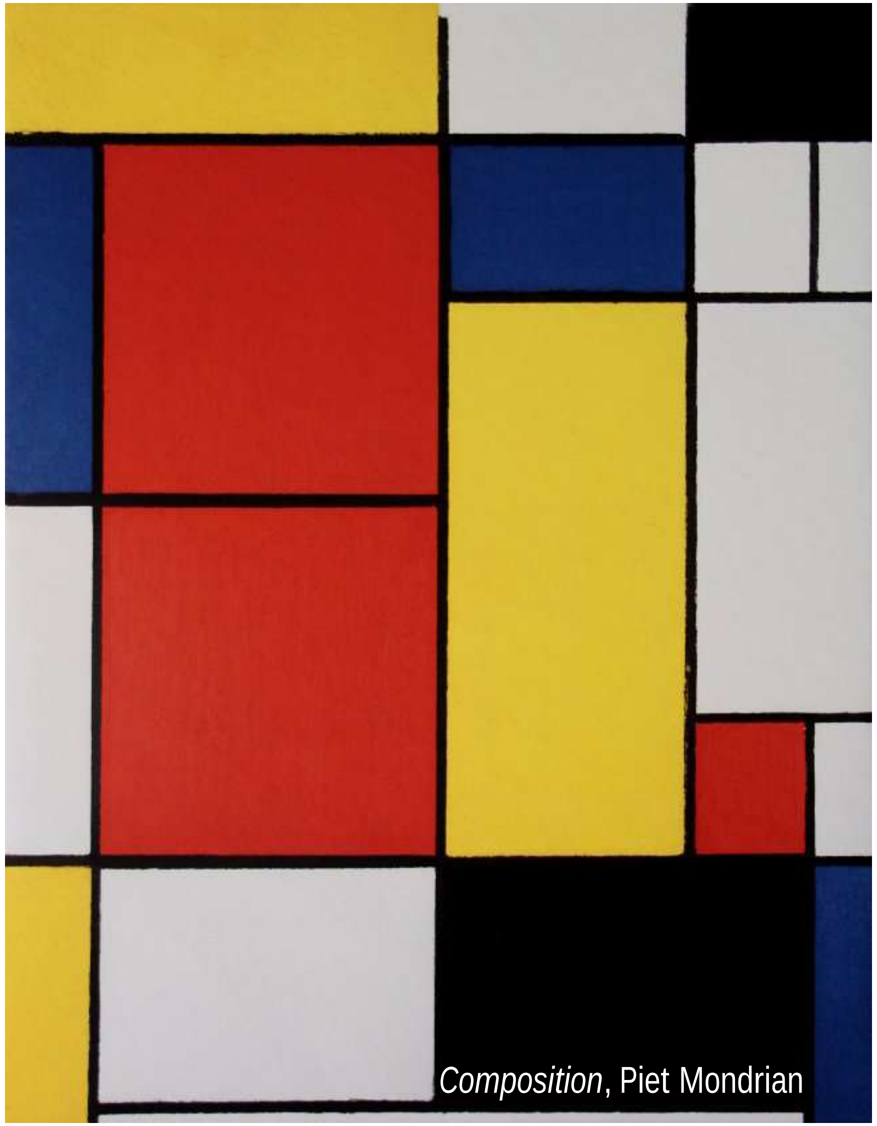

Random matrix

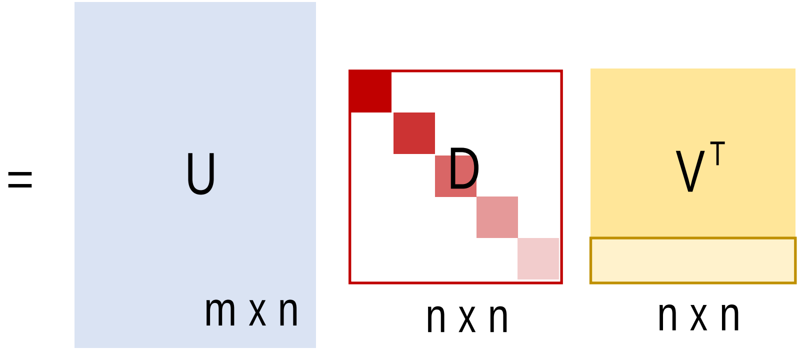
# SVD Matrix Approximation




Reconstructed matrix

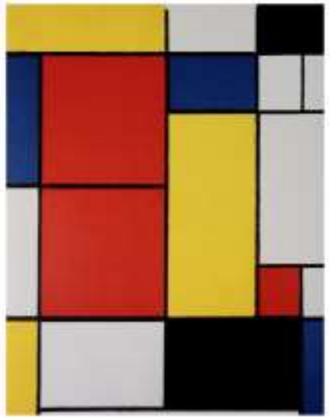
# Mondrian Painting SVD



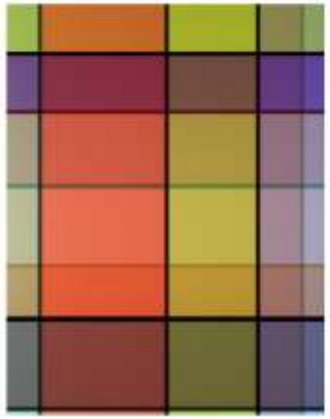



# Mondrian Painting SVD Approximation

MondrianSVD.m



Ground truth

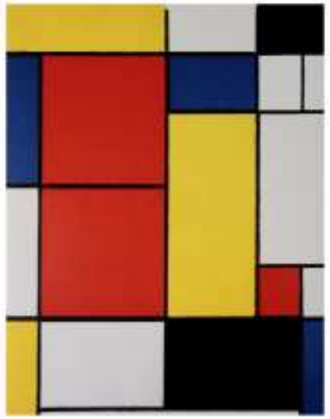


Number of basis: 1

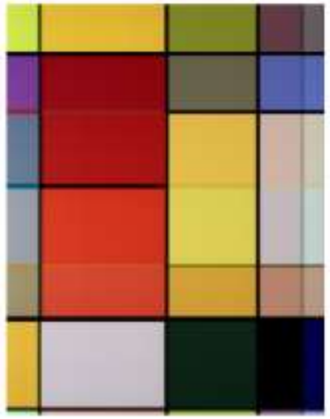
$$A = U \quad D \quad V^T$$

# Mondrian Painting SVD Approximation

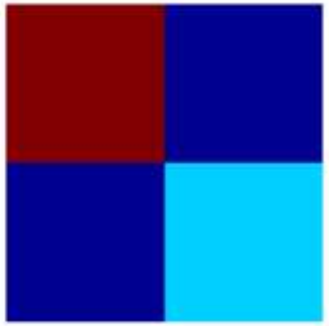
MondrianSVD.m



Ground truth



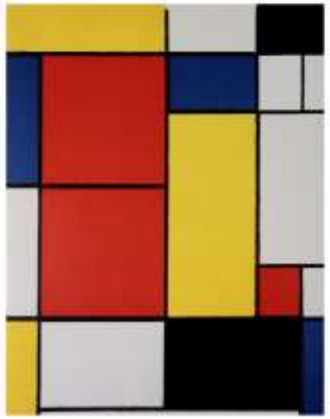
Number of basis: 2



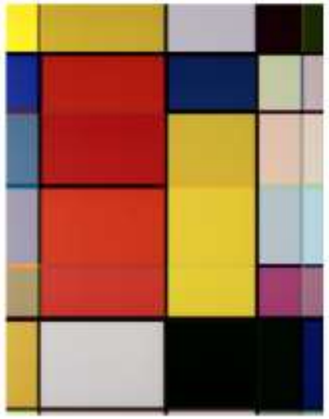
$$A = U \quad D \quad V^T$$

# Mondrian Painting SVD Approximation

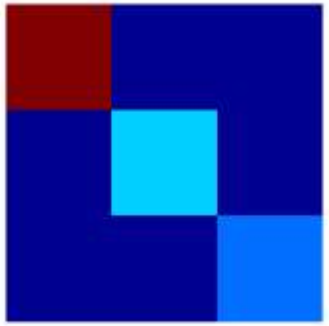
MondrianSVD.m



Ground truth



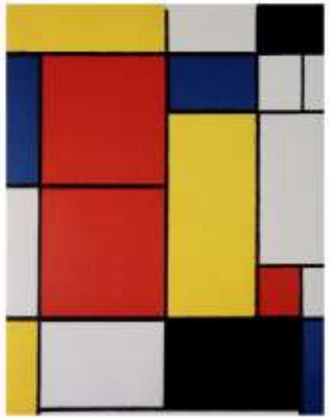
Number of basis: 3



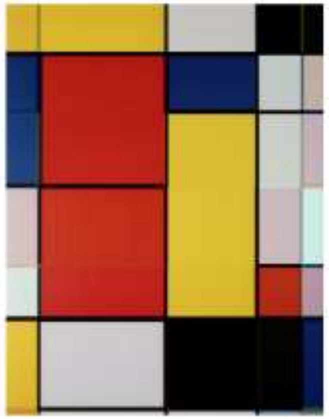
$$A = U \quad D \quad V^T$$

# Mondrian Painting SVD Approximation

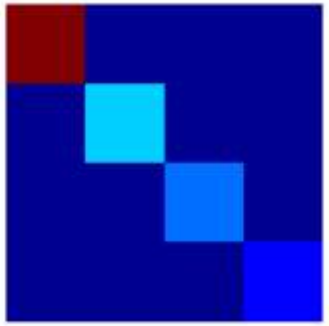
MondrianSVD.m



Ground truth



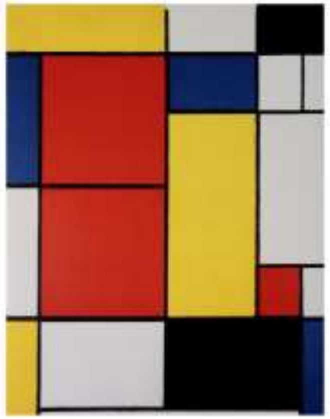
Number of basis: 4



$$A = U \quad D \quad V^T$$

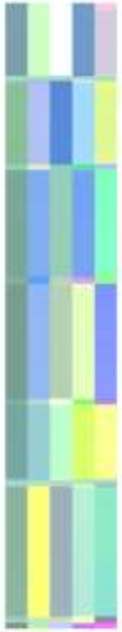
# Mondrian Painting SVD Approximation

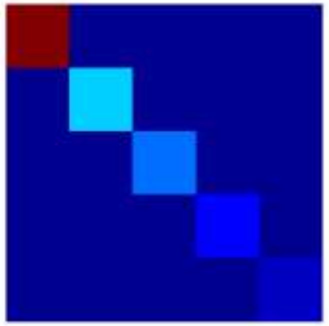
MondrianSVD.m

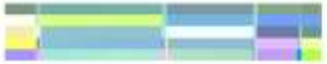


Ground truth

Number of basis: 5



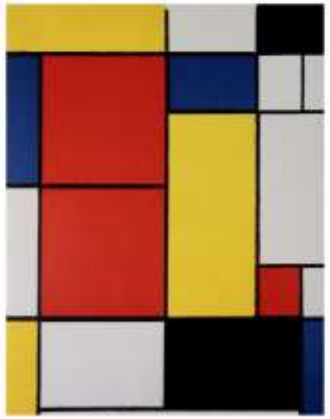




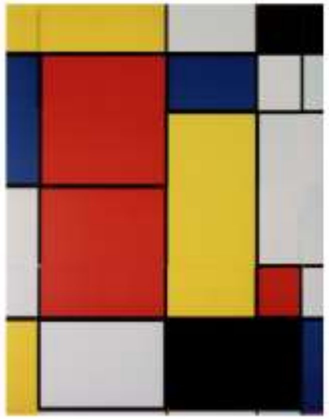
$$A = U \quad D \quad V^T$$

# Mondrian Painting SVD Approximation

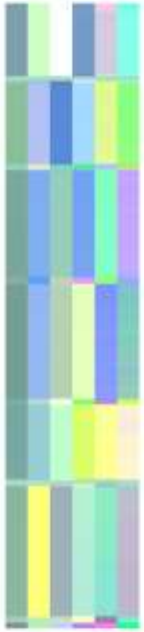
MondrianSVD.m

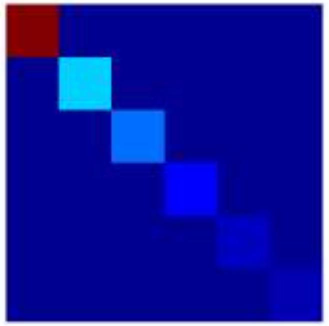


Ground truth



Number of basis: 6

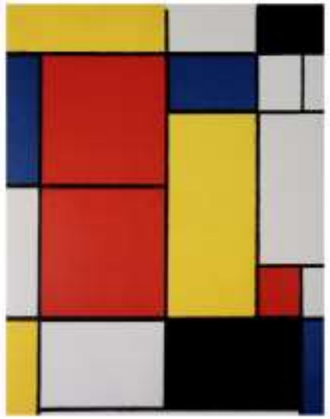




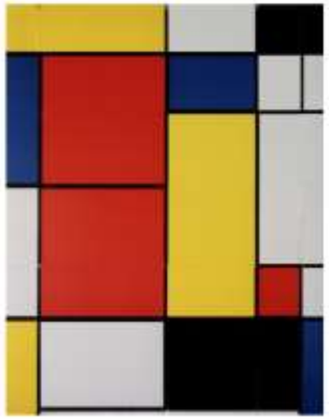
$$A = U \quad D \quad V^T$$

# Mondrian Painting SVD Approximation

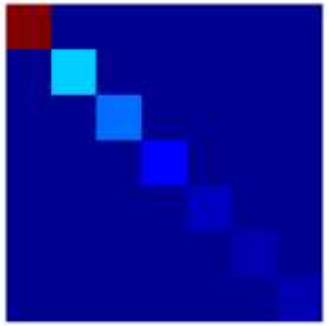
MondrianSVD.m



Ground truth



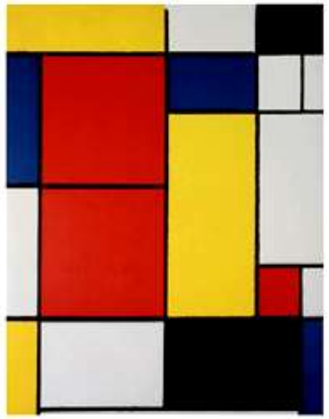
Number of basis: 7



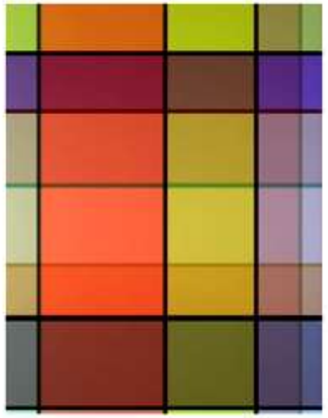
$$A = U \quad D \quad V^T$$

# Mondrian Painting SVD Approximation

MondrianSVD.m



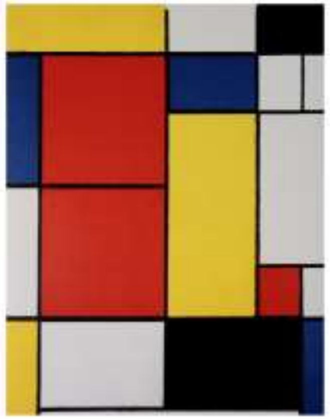
Ground truth



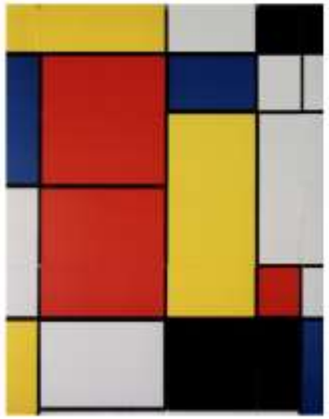
Number of basis: 1

$$A = U \quad D \quad V^T$$

# Reconstruction Error



Ground truth



Number of basis: 7

A

MondrianSVD.m