

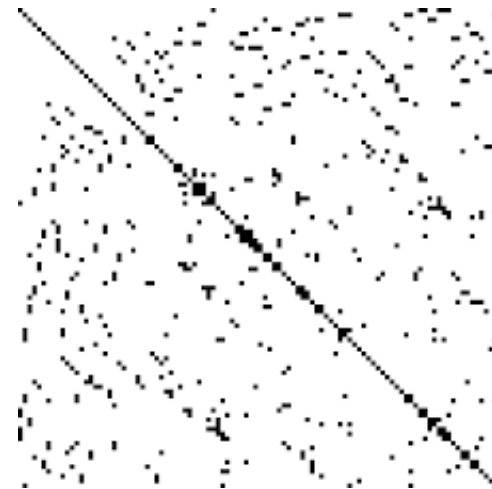


# Sparse Matrices with Linked Lists

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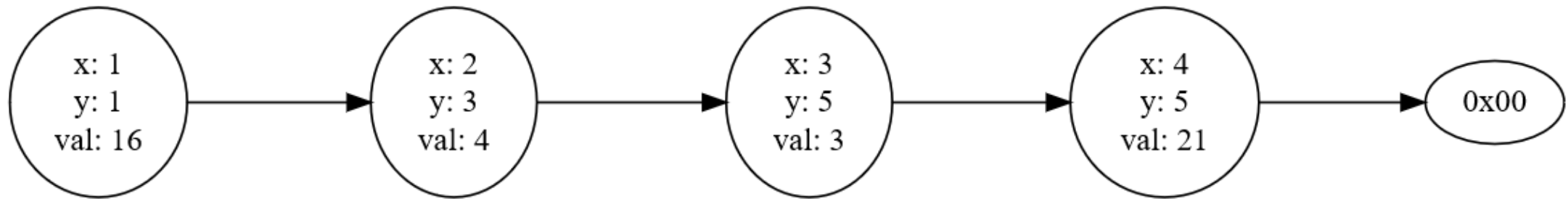
# Sparse Matrices

- Matrices where most of the elements are 0
- Has many applications such as machine learning
- Often these matrices are very large and very few nonzero values



# Linked Lists

- A list of nodes linked together by pointers.
- Contains data field and pointer.



# Linked Lists vs Arrays

- Inserting elements in linked lists do not shift the other elements
- To access node in middle of list, the list needs to be traversed from the first node
- Array are static and linked lists are dynamically sized

# Use of Linked Lists

- Stacks and queues, no need to remove elements from middle
- Photo library apps, each photo is linked to the next.
- Music apps, going through playlist.

# Use of sparse matrices

- Machine learning using large datasets
- Finding word count in a document
- Teams facing each other in soccer world cup

# Append node

- Uses temp pointer that starts at head of list
- Then adds x, y and value fields to object.
- Goes through linked list with temp->next until it equals null.

# Matrix multiplication

- Uses dot product method
- Columns of matrix 1 must equal rows of matrix 2
- Creates a matrix that has the rows of the first matrix and columns of the second matrix

Diagram illustrating the dot product method for matrix multiplication:

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix} \times \begin{bmatrix} 7 & 8 \\ 9 & 10 \\ 11 & 12 \end{bmatrix} = \begin{bmatrix} 58 & \phantom{00} \\ \phantom{00} & \phantom{00} \end{bmatrix}$$

The diagram shows the first row of the first matrix  $[1, 2, 3]$  and the first column of the second matrix  $[7, 9, 11]$  being multiplied together to produce the first element of the resulting matrix, 58. A yellow arrow labeled "Dot Product" points from the first row of the first matrix to the first column of the second matrix, and another yellow arrow points from the resulting value 58 to the first row of the output matrix.



# Matrix Addition

- Adds the corresponding element of the matrices
- Function searches for values of the same coordinates and adds them.

$$\begin{bmatrix} 4 & 8 \\ 3 & 7 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 5 & 2 \end{bmatrix} = \begin{bmatrix} 4 + 1 & 8 + 0 \\ 3 + 5 & 7 + 2 \end{bmatrix}$$

# Transpose

- Takes the  $i^{\text{th}}$  row and makes it the  $j^{\text{th}}$  column.
- Swaps x and y coordinates in linked list for the same value
- Node is then appended for new object

## Transpose of a Matrix



$$A = \begin{bmatrix} a & b & c \\ d & e & f \end{bmatrix}_{2 \times 3}$$

$$A^T = \begin{bmatrix} a & d \\ b & e \\ c & f \end{bmatrix}_{3 \times 2}$$

# Scalar

- Every value of node is multiplied by scalar.
- Traverses through list and appends x, y and new value fields to new object

$$2 \cdot \begin{bmatrix} 10 & 6 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} 2 \cdot 10 & 2 \cdot 6 \\ 2 \cdot 4 & 2 \cdot 3 \end{bmatrix}$$



# Code *Demonstration*

# Sources

- <https://www.mathsisfun.com/algebra/matrix-multiplying.html>
- <https://www.khanacademy.org/math/prec calculus/x9e81a4f98389efdf:matrices/x9e81a4f98389efdf:adding-and-subtracting-matrices/a/adding-and-subtracting-matrices>
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- <https://www.cuemath.com/algebra/transpose-of-a-matrix/>