

Final Project

Song Liu (song.liu@bristol.ac.uk)

GA 18, Fry Building,

Microsoft Teams (search "song liu").

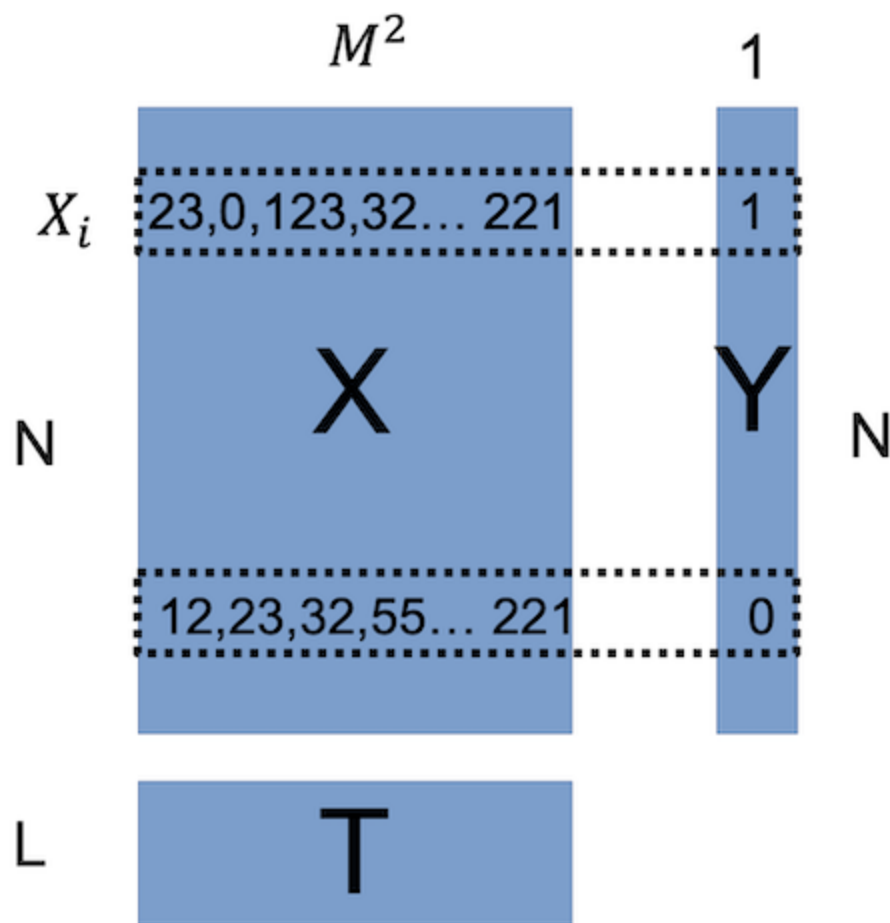
Final Project: "Recognising" Images

- In this final project, you will write a program that "recognises" handwritten digits.
- Given **test images**, your program guesses whether these images are digit "1" or not.
 - The "guessing" is done using the *k*-nearest neighbours algorithm, a widely known machine learning algorithm.
- This project worth 12.5% of your total score in this unit.
 - You will get a score from 0-100.
- Read the instructions and the skeleton code before you start.

Part I, The Data Set

- The CW folder contains 3 `.matrix` files storing 3 matrices.
 - `X.matrix` stores an N by M^2 matrix X where each row is a grayscale M by M image stored in row-major order.
 - `Y.matrix` stores an N by 1 matrix Y where each row is a scalar, indicating whether the corresponding row in X is digit 1 or not.
 - `T.matrix` stores an L by M^2 matrix T where each row is an M by M **test image** in row major order.
 - X and Y together are called "training set" in machine learning, while T is the "testing set". Y is called the "labels" of X .

Part I, Data Structure



- If $Y_i = 1$, then the image X_i is a handwritten digit 1. If $Y_i \neq 1$, the image X_i is NOT a handwritten digit 1.

Part I, Loading Dataset

- The code for loading these images from files have been provided to you. Matrices are represented by a **matrix structure** in this coursework.

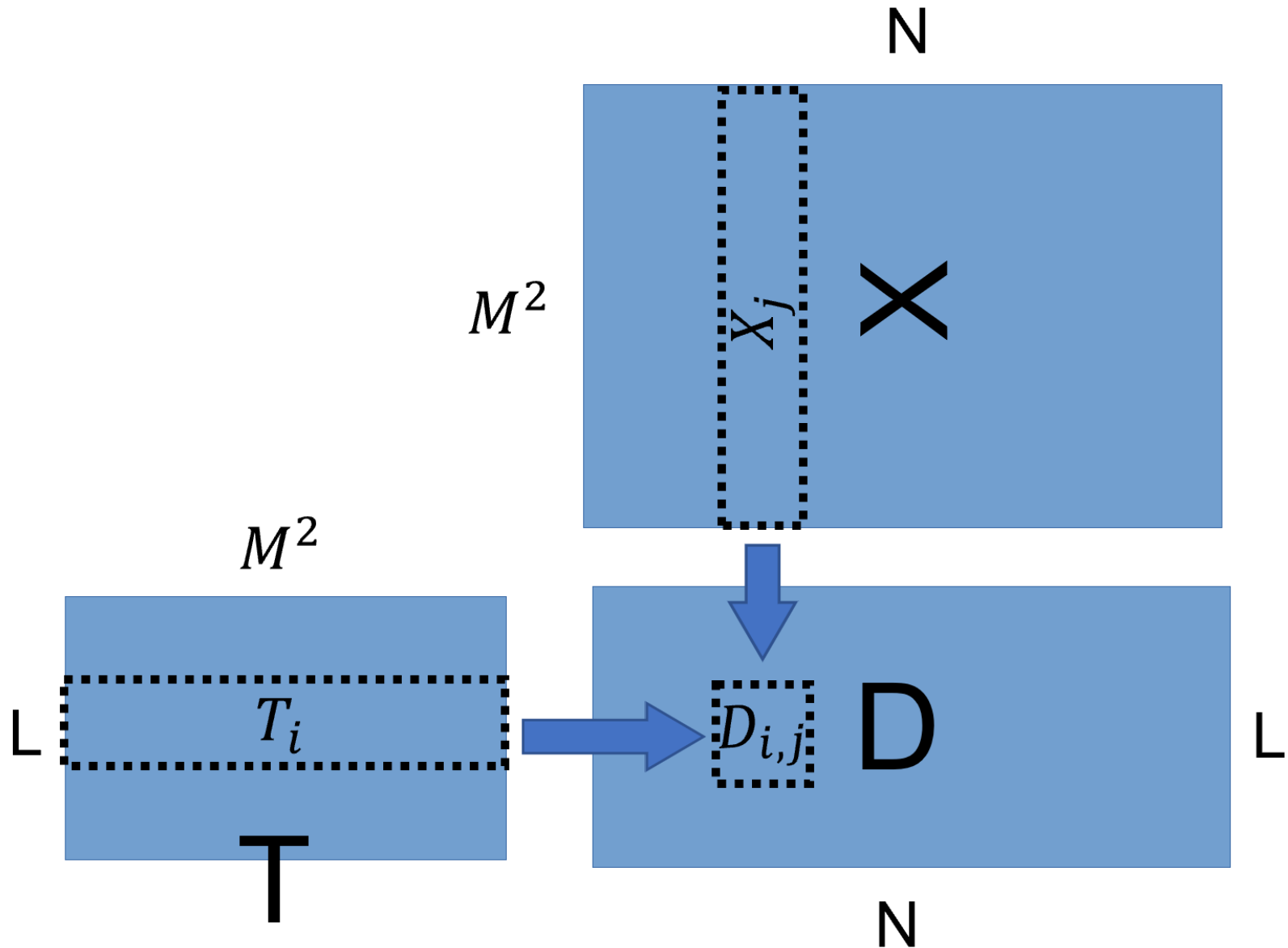
```
struct matrix
{
    int numrow; //number of rows
    int numcol; //number of columns
    int *elements; // pointer pointing to an integer array
    // storing all entries in the matrix.
};
typedef struct matrix Matrix;
// now "Matrix" is an alias of "struct matrix"
```

- By simply running the skeleton code, you should see some basic statistics of X , Y and T .
 - What are M , N and L ?
 - How many images in the training set X are digit 1?

Part II Computing Distance Matrix D (40pt in total)

- Construct an L by N matrix D , where the i, j -th element $D_{ij} = \text{dist2}(T_i, X_j)$
 - T_i is the i -th row of T .
 - X_j is the j -th row of X
- $\text{dist2}(a, b)$ computes the squared euclidean distance between two vectors a and b with K elements.
 - $\text{dist2}(a, b) := \sum_{k=1}^K (a_k - b_k)^2$.

Part II (Computing D)



Part II.1 (15pt) Constructing D

In your `main` function,

1. Allocate HEAP memory for D .
2. Declare and initialize a new `matrix` variable `D`.

Before your `main` function,

3. Write a few helper functions:

- `int get_elem(Matrix M, int i, int j)`

returns the `i, j` th element of matrix `M`.

- `void set_elem(Matrix, int i, int j, int value)`

assign `value` to the `i, j` th element of matrix `M`

In this coursework, `i, j` are zero-based indices.

Part II.2 Computing D (25pt)

Now, populate the matrix D with correct values.

- **Hint:** Compare the computation of D and the matrix multiplication. What are the similarities and what are the dissimilarities?
 - Can you modify the matrix multiplication code to compute matrix D ?

- **Hint,** you can write a function

```
void pairwise_dist(Matrix T, Matrix X, Matrix D)
```

- where D is the output, storing the outcome.
- Partial points will be given for correctly written code for computing $\text{dist2}(a, b)$.

Part III.1 Guessing Labels (15%)

In the `main` function,

- For each row of matrix D , find **the indices** of the five smallest elements.
 - Suppose the i -th row of D is
 $[3, 2, 5, 1, 2, 5, 13, 46, 32]$,
 - The indices of the five smallest elements are
 $[3, 1, 0, 5, 6]$.
- Hint: Write a function

```
void minimum5(int len, int a[], int indices[]),
```

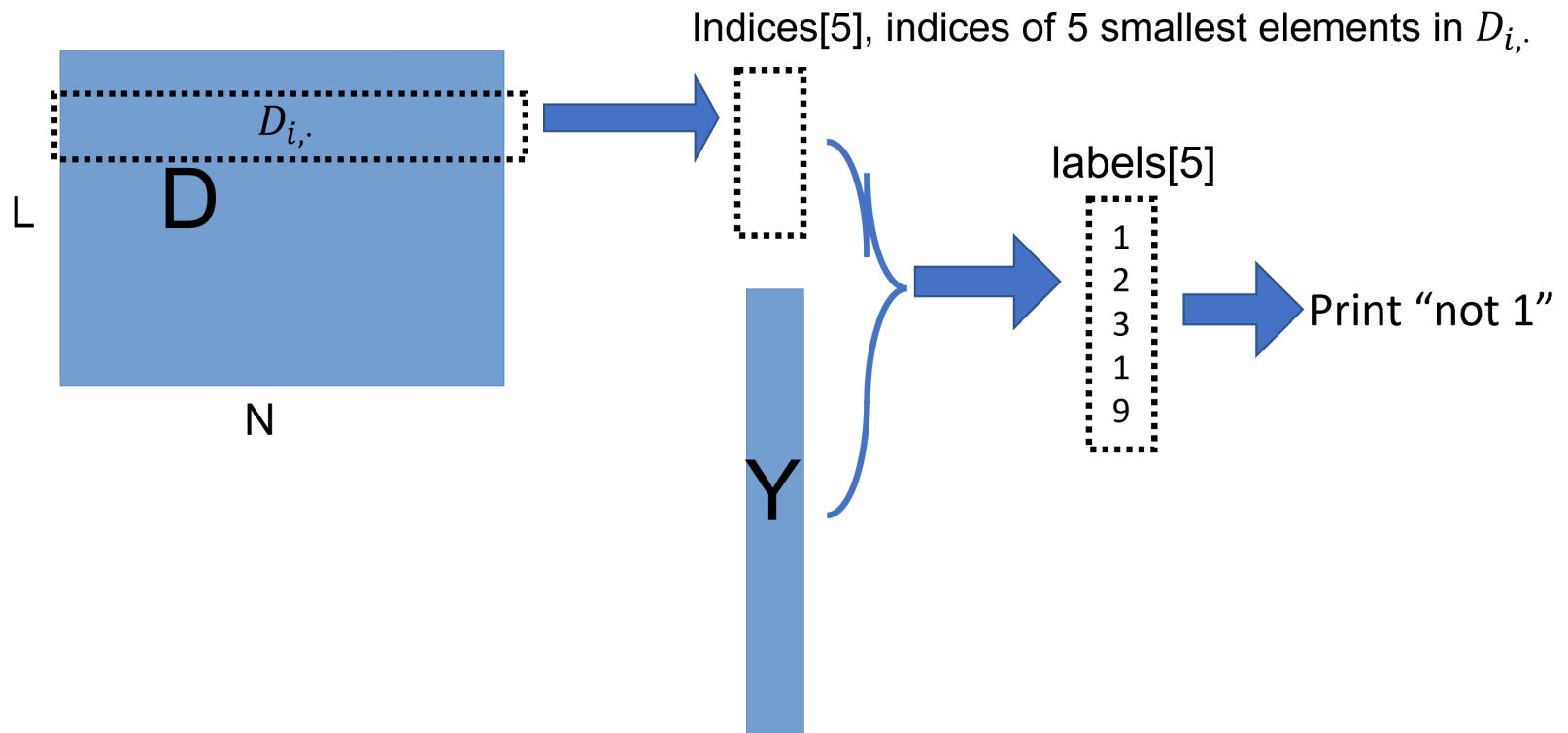
It takes an array `a` with length `len` as input, then fills `indices[]` with the indices of the five smallest elements.

Part III.2 Guessing Labels (15%)

- Now, suppose the array `indices` contains the indices of the five smallest elements in row i of matrix D .
 - Create a new array `labels` with length 5.
 - Assign the value of $Y_{\text{indices}[i],0}$ to the i -th element in `labels`.
 - Count the number of `1` in `labels`.
- If the count ≥ 3 , print out `1`. Otherwise, print `not 1`.
- Repeat above for all rows in D .

Part III Guessing Labels (30pts total)

For each row in D , do:



Part III Guessing Labels

- During Part III, at each row D_i , the print-out your "guess" of the testing image T_i using 5-nearest neighbour algorithm.
 - If the print-out is 1, it means the algorithm thinks the image T_i is a digit 1.
 - If the print-out is not 1, it means the algorithm thinks the image T_i is NOT a digit 1.
- After your guess, you can optionally print the image stored in T_i to the console to validate your guess.

Part III Guessing Labels

- Hint: Write pseudo code for Part III before writing the real code.
- You might want to test your functions in a separate c file to ensure that they are correctly written.

Final Project: Marking Criteria

- Submitting correct code (10%)
 - Submitting a C file with **the correct name**.
 - Your code compiles and runs **without major error** such as **crash, infinite loop**.
 - It will be tested using `gcc` in the lab pack.
- Part II 40% (15% + 25%)
- Part III 30% (15% + 15%)
- Good Coding Practice (20%)
 - Good code format
 - Good variable naming scheme.
 - Apt comments

Final Project: Dos and Don'ts

- You can discuss with your classmates about general strategies but write your own code!
- Don't give your code to other students.
- Review relevant previous lab sessions before you start.
- You can use whatever material you can find to help you complete the task, but you need to add a reference in the comments.
- You are only allowed to use standard features of C.
 - You can use `stdio.h`, `stdlib.h`, `limits.h` and `math.h`.
 - If you want to use other libraries, consult with the lecturer or TA beforehand.

Final Project: Q&A

- We will answer questions posted on the Blackboard forum or answering them during the lab sessions.
- We will inspect the forum regularly and try to respond in 24 hours.

