Image sharpening exercise

Running a simple parallel program

Reusing this material

Aims (i)

- To familiarise yourself with running parallel programs

- To run a real parallel code (that does file I/O)
  - On different numbers of cores
  - Measure the time taken
  - Observe increase in performance (Amdahl's law? – see later)

- Acknowledgements
  - Algorithm, diagrams and images taken from:
  - *Hypermedia Image Processing Reference*, Bob Fisher, Simon Perkins, Ashley Walker and Erik Wolfart, Department of Artificial Intelligence, University of Edinburgh (1994)

Aims (ii)

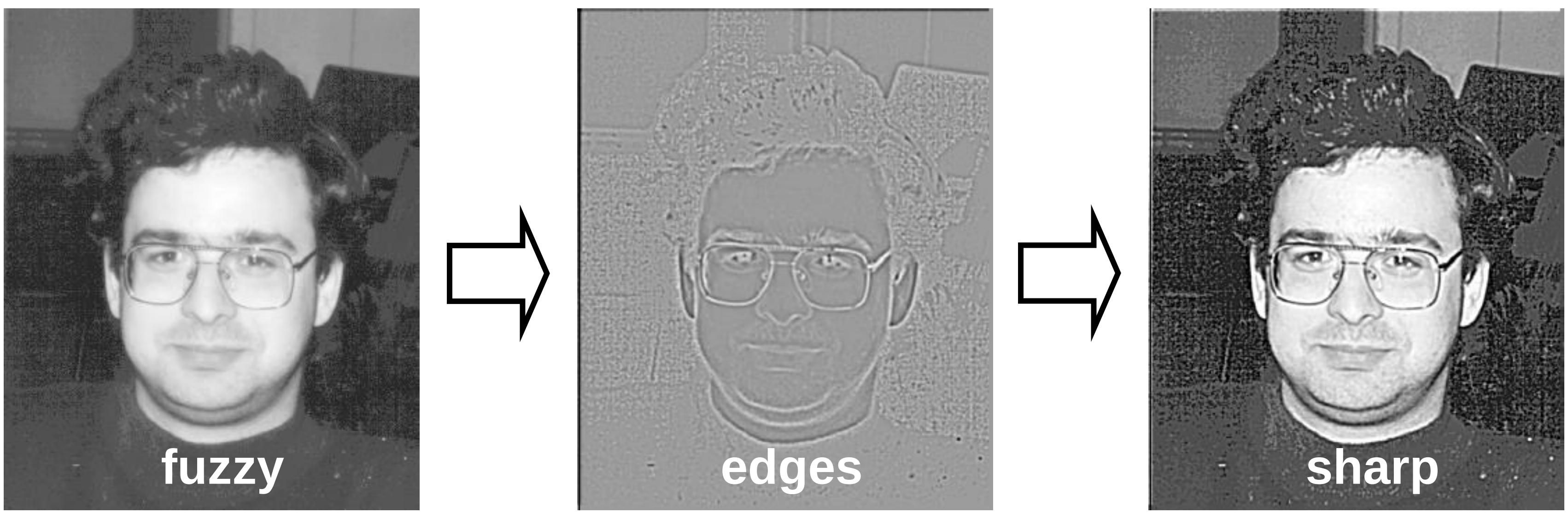
- To get you running on the machine
- To sort out all the practical details
  - usernames
  - passwords
  - graphics
  - transferring files
  - using the batch system
  - idiosyncrasies of your Windows / Mac / Linux laptop
- Please ask for assistance if you need it!
  - Demonstrators are here to help with all aspects of course

The image sharpening problem

Algorithm and implementation

Image sharpening

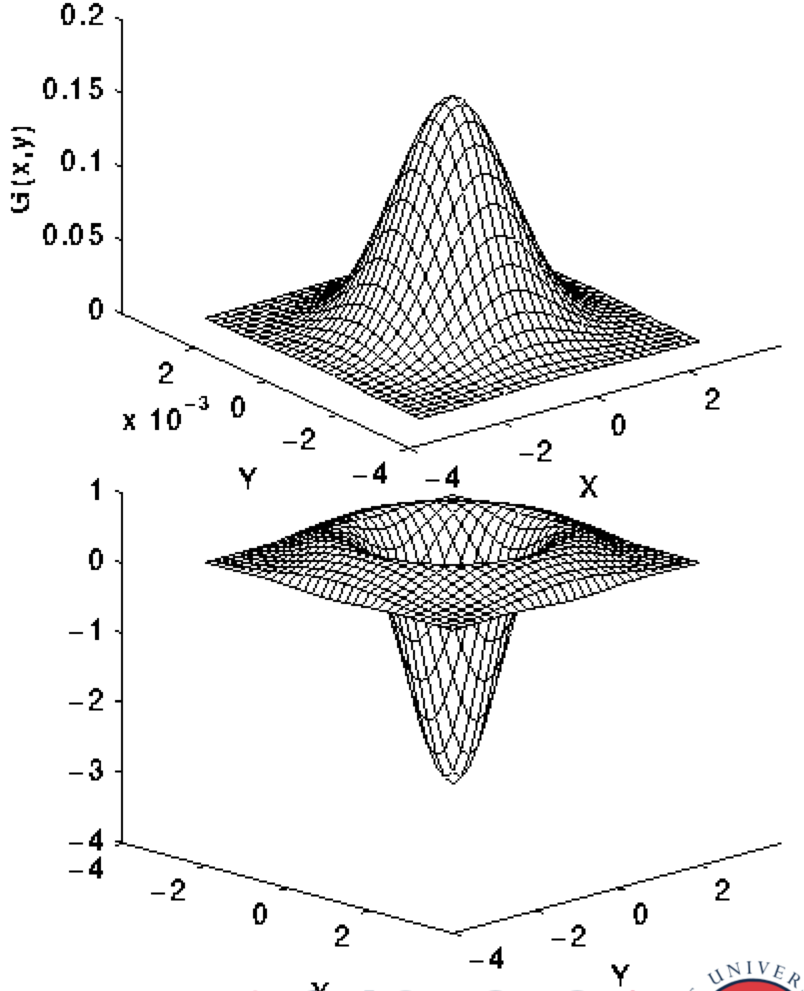
- Images can be fuzzy for two main reasons
  - random noise
  - blurring
- Aim to improve quality by
  - smoothing to remove noise
  - detecting edges
  - sharpening up the image with the edges



Technicalities

- Each pixel replaced by a weighted average of its neighbours
  - weighted by a 2D Gaussian
  - averaged over a square region

  - we will use:
    - Gaussian width of 1.4
    - a 17x17 square
  - then apply a Laplacian
    - this detects edges
    - a 2D second-derivative ∇^2



- Combine both operations
  - produces a single convolution filter

Implementation

- For over every pixel in the image
  - loop over all pixels in the 17x17 square surrounding it
  - add in the value of the pixel weighted by a filter

$$edge(i,j) = \sum_{k,l=-8,8} image(i+k, j+l) \times filter(k,l)$$

- This gives the edges
  - add the edges back into the original image with some scaling factor
    - we use 2.0
  - rescale the sharpened image so pixels lie in the range 0 - 255

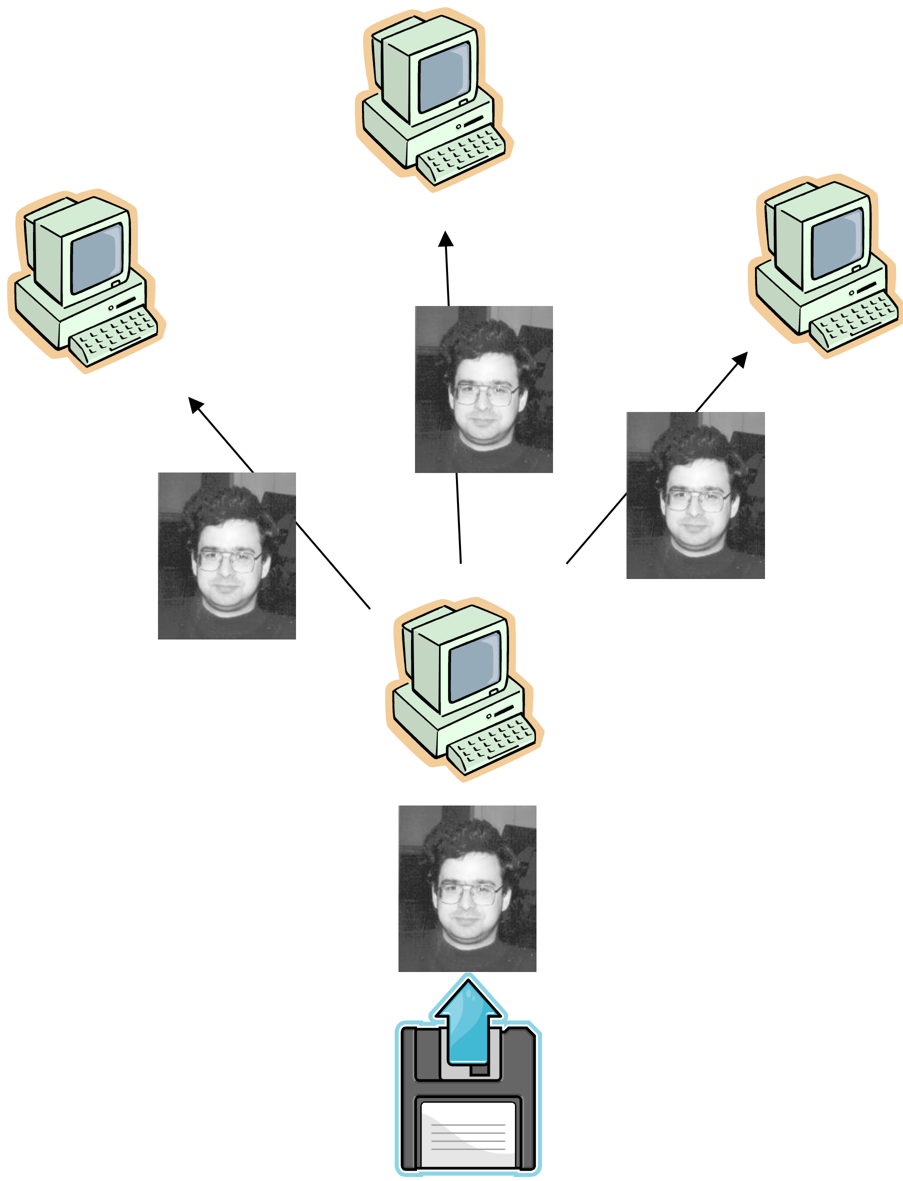
Existing parallelisation

How the code takes advantage of multiple processors

Parallelisation

- Each pixel can be processed independently
- A master process reads the image
- Broadcast the whole image to every process
- Each process computes edges for a subset of pixels:
  - scan the image line by line
  - with four processes, each process computes every fourth pixel
- Combine the edges back onto a master process
  - add back into original image and rescale
  - save to disk
- Reports two times:
  - calculation time for just computing edges on each process
  - overall time for the whole program including IO

Parallelisation



1	2	3	4	1
2	3	4	1	2
3				

A number of implementations provided

- Supply a serial version for reference
- Parallelisation is achieved using message-passing model
- Implemented using MPI
  - the Message-Passing Interface

- Another version parallelised using shared-variables model
- Implemented using OpenMP
  - HPC standard for threaded programming
  - for interest - not critical to this exercise

- These concepts will be explained later in the course …

Miscellaneous notes

Extra stuff to help you with the practical

PBS job submission scripts (ARCHER)

```
#PBS -N sharpen
#PBS -l select=1
# now stuff that actually executes
…
aprun -n 4 ./sharpen
```

name for PBS batch job

how many *nodes* you want

program to run

parallel job launcher

how many *cores* to run on – remember 24 cores per node!

PBS job submission scripts (Cirrus)

```
#PBS -N sharpen
#PBS -l place=excl
#PBS -l select=1:ncpus=72

# now stuff that actually executes
…
mpiexec_mpt -n 4 -ppn 4 ./sharpen
```

name for PBS batch job

exclusive access – no other users on node

how many *nodes* you want

program to run

number of Processes Per Node

parallel job launcher

how many *cores* to run on – remember 36 cores per node!

Compiling and Running

- We provide a tar file with code (C or Fortran) and image
  - copy tar file it to your local account
  - unpack it
  - compile it
  - run it on the back end using appropriate batch scripts
  - view the input and output images using **`display`** program
  - note the times for different numbers of processors
    - can you interpret them?