

Image sharpening exercise

Running a simple parallel program

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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)

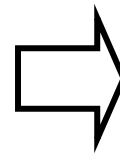
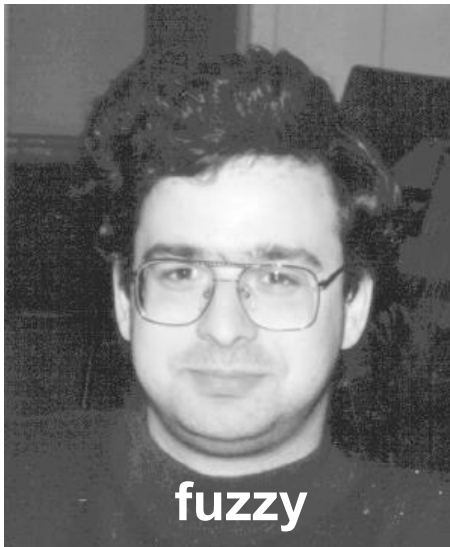
- To get you running on the machine
- To sort out all the practical details
 - usernames
 - passwords
 - graphics
 - transferring files
 - using the batch system
 - idiosyncrasies of your Windows / Mac / Linux laptop
- Please ask for assistance if you need it!
 - Demonstrators are here to help with all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

The image sharpening problem

Algorithm and implementation

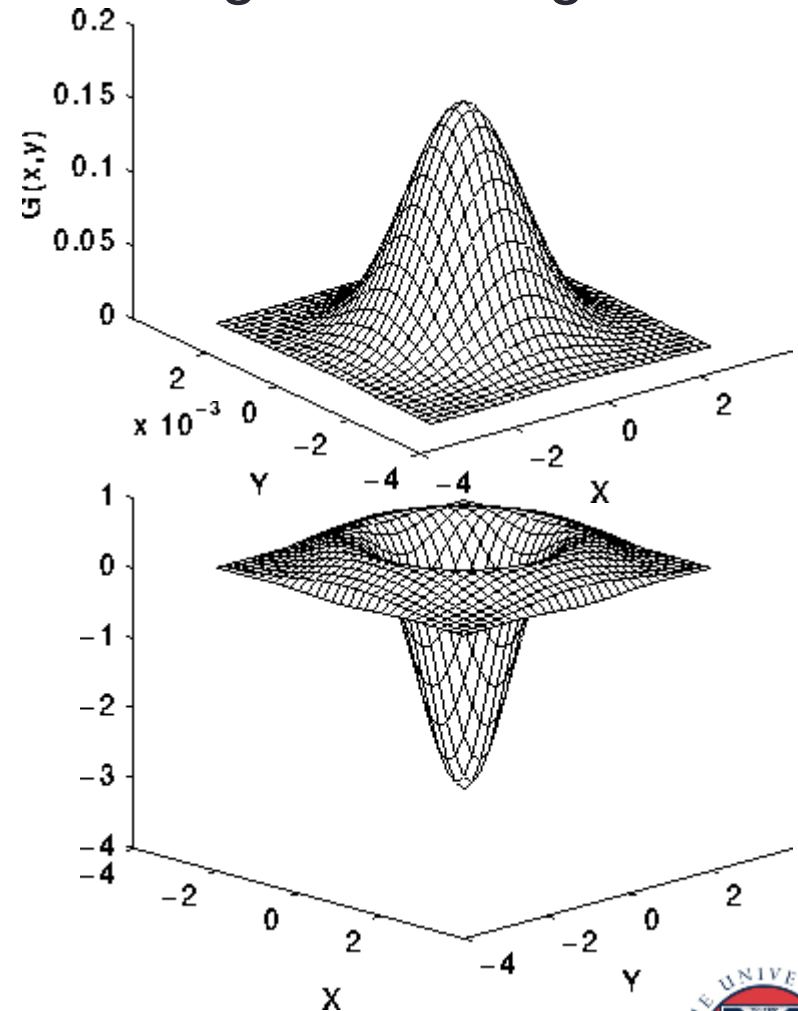
Image sharpening

- 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 large square region
- 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 a large area surrounding it
 - up to distanced d away in each direction: $2d+1 \times 2d+1$ square
 - we use $d = 8$, i.e. a 17×17 square
 - add in the value of the pixel weighted by a filter

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

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

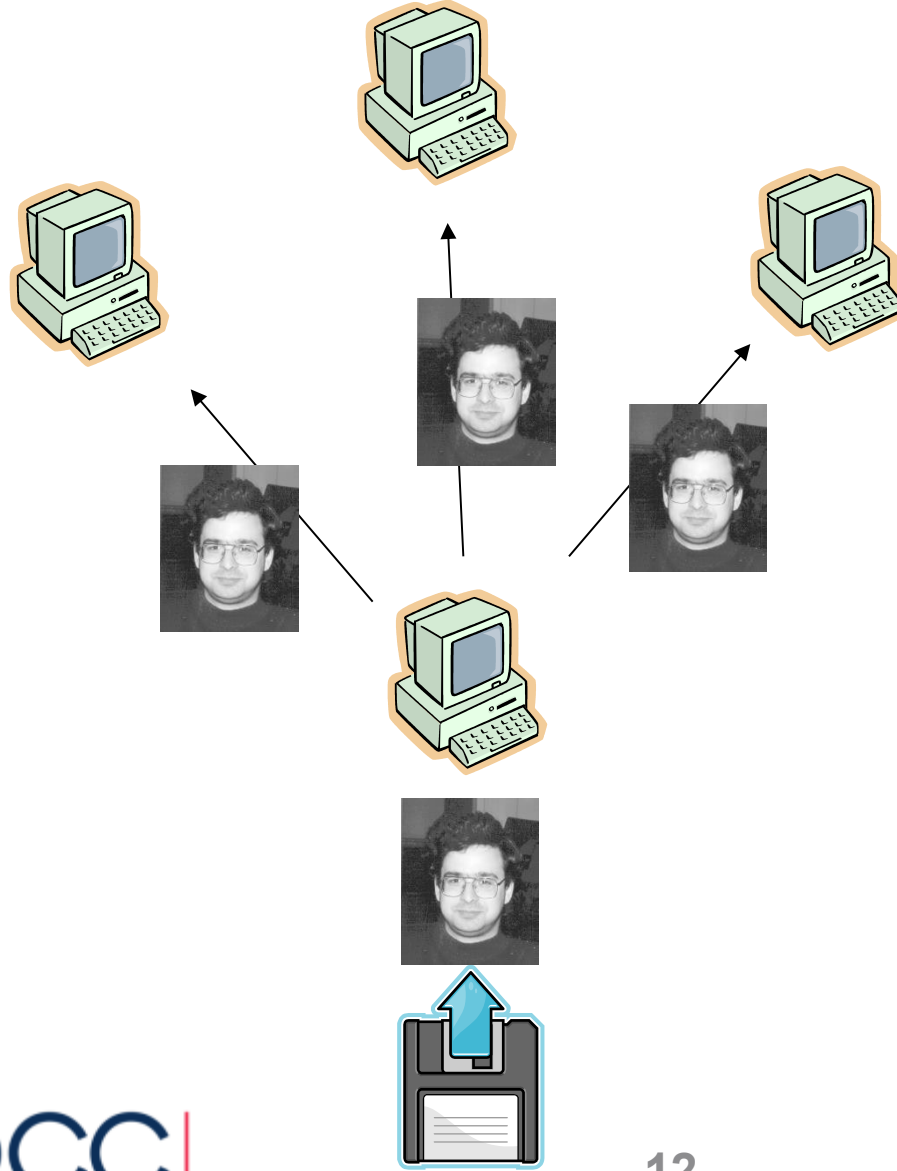
Existing parallelisation

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

Slurm job submission scripts (Cirrus)

```
#SBATCH --job-name=sharpen
#SBATCH --nodes=1
#SBATCH --ntasks=4
#SBATCH --tasks-per-node=4
# now stuff that actually executes
...
srun --cpu-bind=cores ./sharpen
```

name for Slurm batch job

how many *nodes* you want

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

number of Processes Per Node

program to run

parallel job launcher

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?