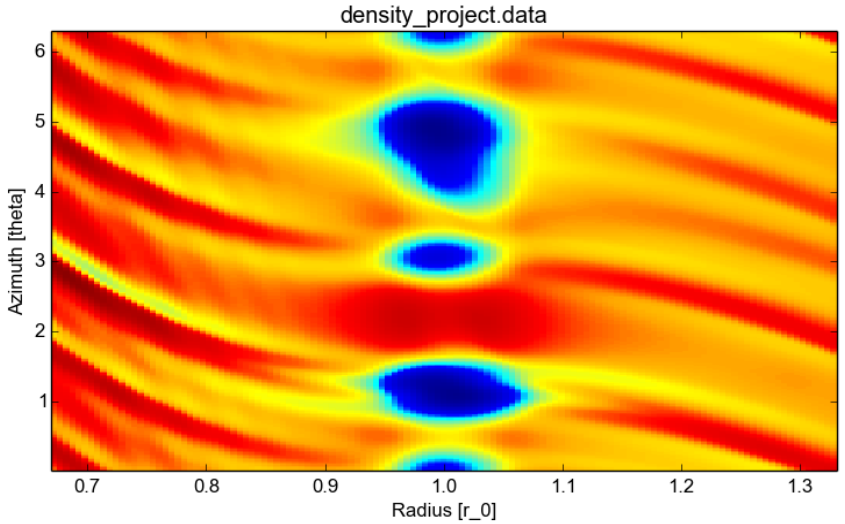
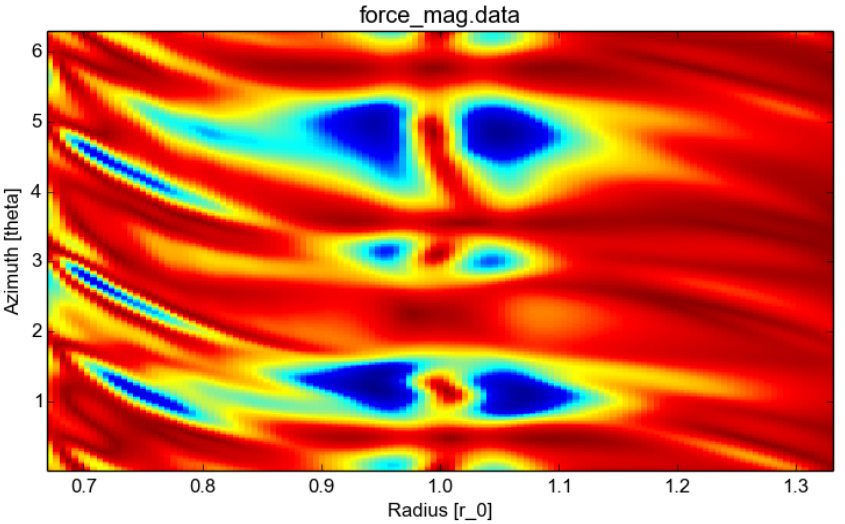
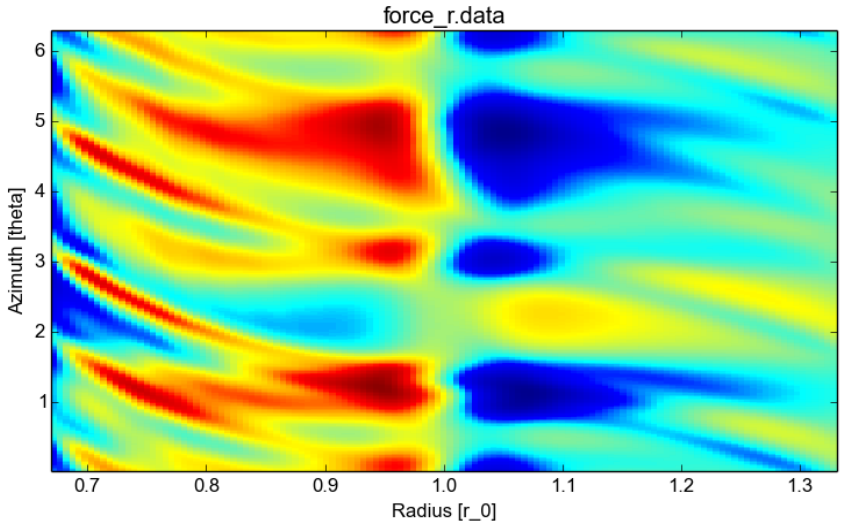
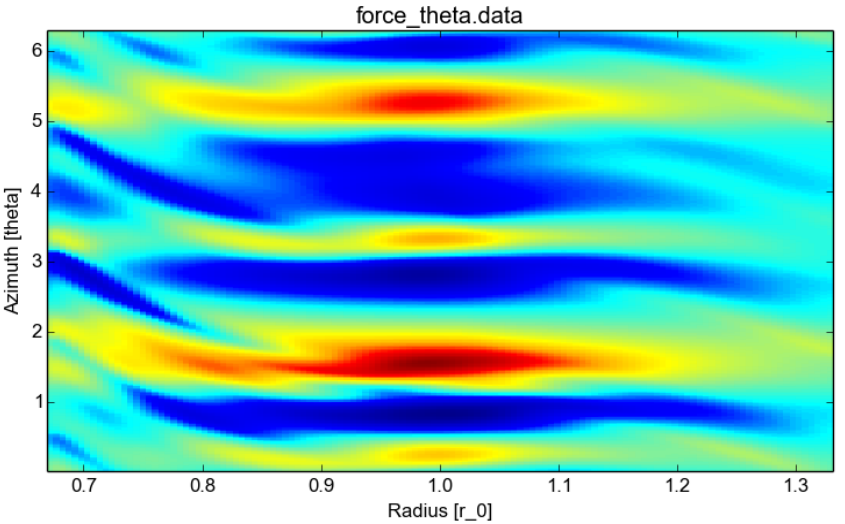
Computational Science II









Preliminary Optimisation Report

By: Sara Vossoughi

$$\sum\sum \frac{G(r',\theta')\,r'\cdot\Delta r'\cdot\Delta\theta'}{\left(r^2+r'^2-2\cdot r\cdot r'\cos(\theta-\theta')\right)^{(2/3)}} \begin{Bmatrix} u_r = r - r'\cdot\cos(\theta-\theta') \\ u_\theta = r'\cdot\sin(\theta-\theta') \end{Bmatrix}$$

Runtime Performance*

$O(n^2)$ worst performance: ~ 69.0s**

↓

$O(n^2)$ best performance: ~ 11.8s

* 3 year old intel laptop with four 2.2GHz cores (i7 2620M)

** With inner loop time measurements, the process did not complete

Optimizations

First Culprit: Trigonometry

- Over 1 billion calls to sine and cosine
- Only 256 distinct angles $(i \cdot \Delta\theta)$
- Symmetry of sine and cosine

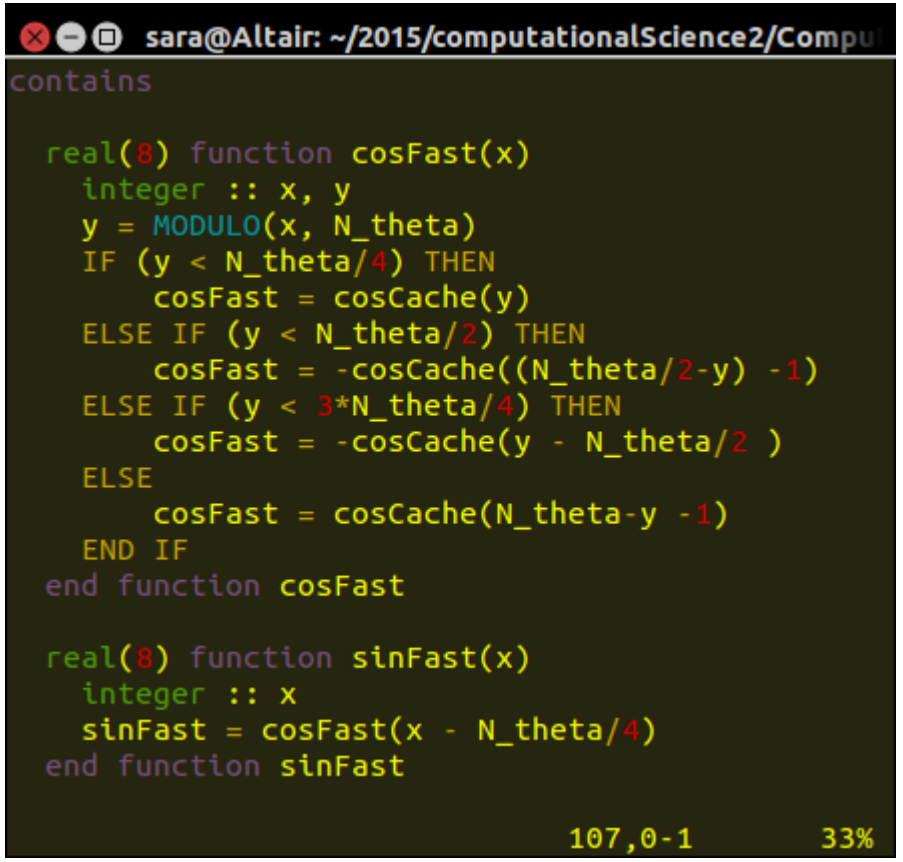
Moving operations from inner to outer loop

- Certain calculations are constant within the inner loop

Choosing Cheaper Operations

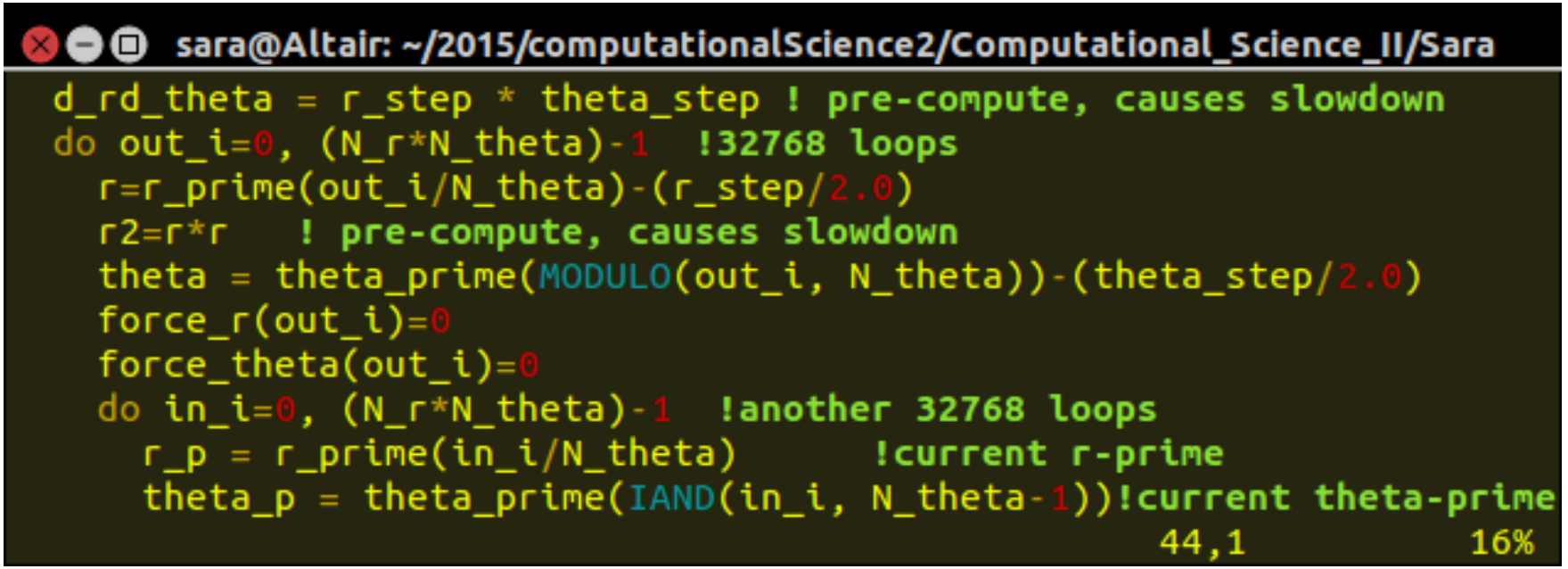
- IAND vs. Modulo
- Multiplications vs. power operator (x**y)
- Sqrt(x) over power operator

Optimizations Continued



- CosCache is an array of 64 (N_theta/4) pre-computed cosine values
- Fewer memory requirements, more logic
- Can possibly be further optimised with hardcoded constants (N_theta/2) with larger array
- SELECT CASE did not provide an improvement

Optimization



- Moving variables outside the inner loop
- Pre-computing values
- Using cheaper operations IAND

Results*

- Trigonometric caching (256 distinct values): 68s → 20s
- Compiler optimization settings (-O3 & -O): 20s → 11.8s
- Trigonometric symmetry: 20s → 25s
- Moving instructions to outer loops: +1-2s ??
- Using cheaper operations: inconclusive measurements/no change

* FORTRAN noob, your mileage may vary

Conclusions

Best performances achieved

- Compiler tweaking (-O3 or -O flags)
- Caching trigonometric functions

No change or slowdown

- Trigonometric symmetry costs a slowdown
- Moving computations to outer loop had little effect
- Bitwise AND vs. Modulo computation in inner loop had no effect

This is largely a trial and error endeavor.