

Numerical Techniques for Fluid Dynamics

MATH5453M FEM Numerical Exercises 3, 2024

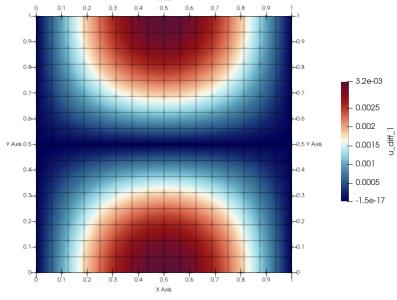
Aly Ilyas

mmai@leeds.ac.uk

Due date: December 2024

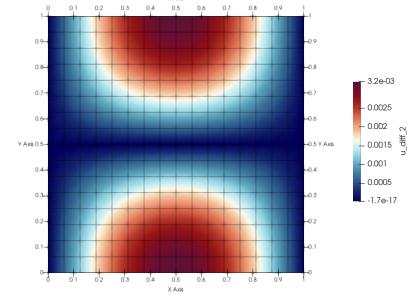
Appendix 2: Numerical errors comparison

Method 1 Errors

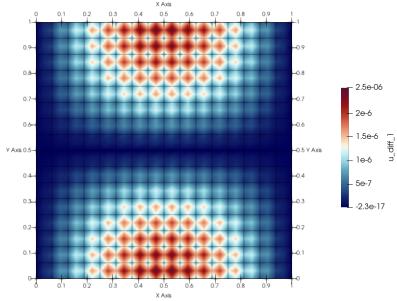


(a) $p = 1, 16 \times 16$

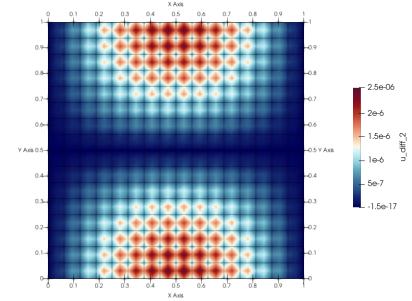
Method 2 Errors



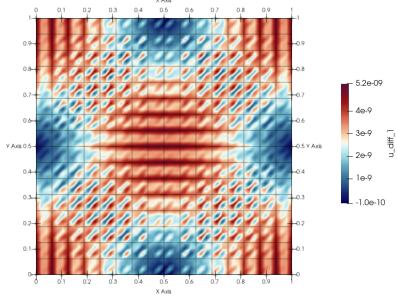
(b) $p = 1, 16 \times 16$



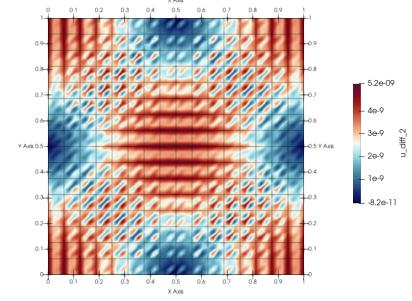
(c) $p = 2, 16 \times 16$



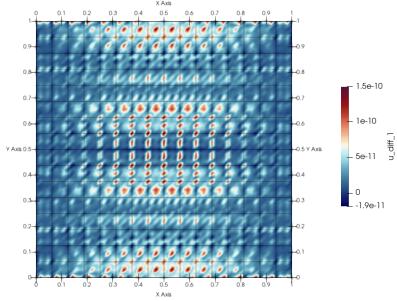
(d) $p = 2, 16 \times 16$



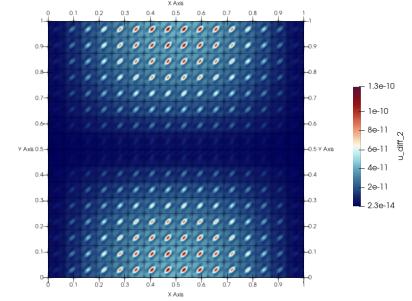
(e) $p = 3, 16 \times 16$



(f) $p = 3, 16 \times 16$



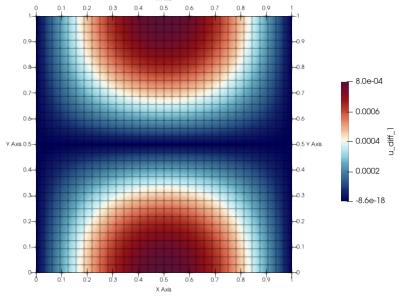
(g) $p = 4, 16 \times 16$



(h) $p = 4, 16 \times 16$

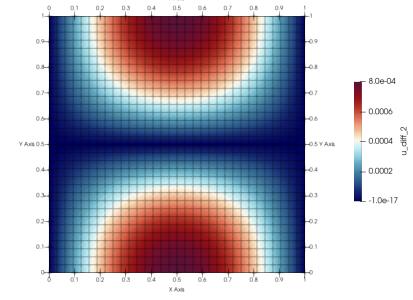
Figure 7: Comparison of numerical error for Method 1 and Method 2 for mesh resolutions of 16×16 and different polynomial orders ($p = 1$ to $p = 4$).

Method 1 Errors

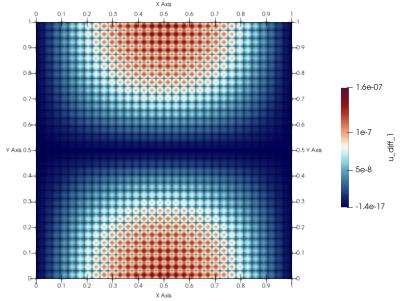


(a) $p = 1, 32 \times 32$

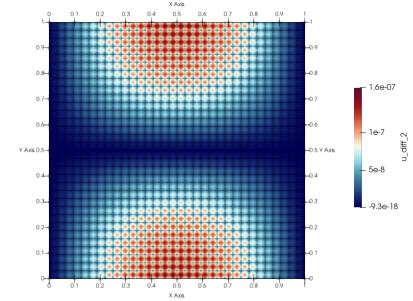
Method 2 Errors



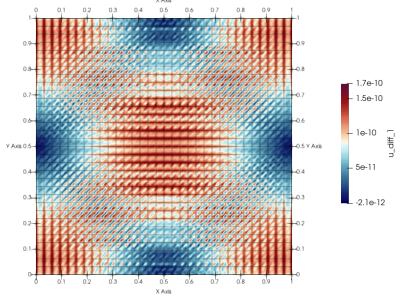
(b) $p = 1, 32 \times 32$



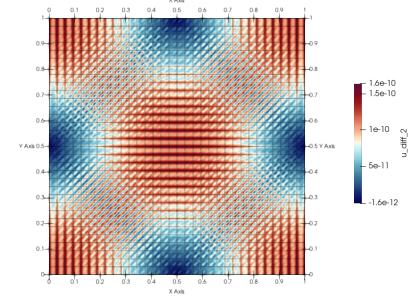
(c) $p = 2, 32 \times 32$



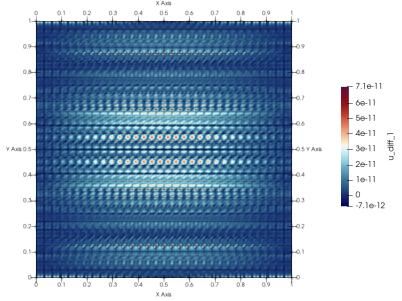
(d) $p = 2, 32 \times 32$



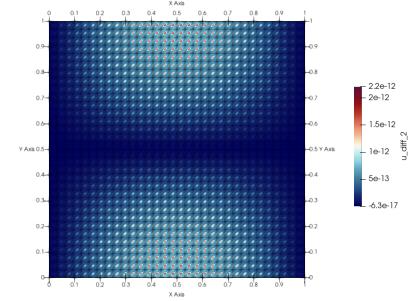
(e) $p = 3, 32 \times 32$



(f) $p = 3, 32 \times 32$



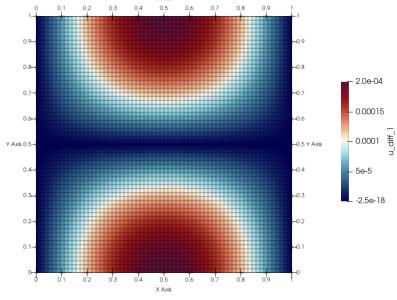
(g) $p = 4, 32 \times 32$



(h) $p = 4, 32 \times 32$

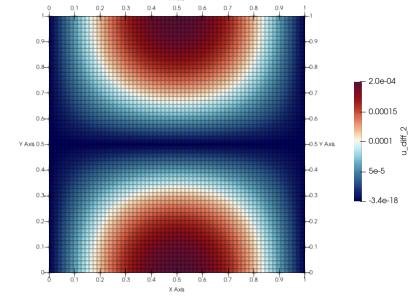
Figure 8: Comparison of numerical error for Method 1 and Method 2 for mesh resolutions of 32×32 and different polynomial orders ($p = 1$ to $p = 4$).

Method 1 Errors

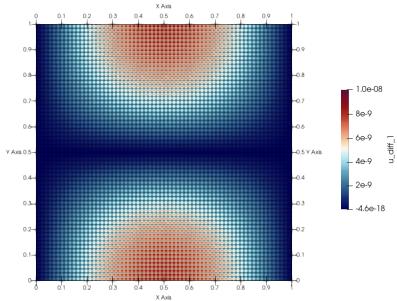


(a) $p = 1, 64 \times 64$

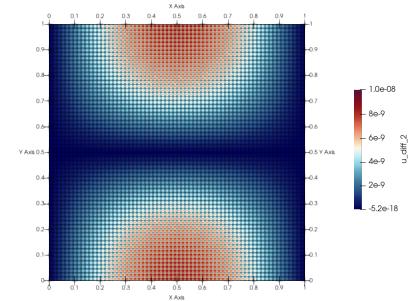
Method 2 Errors



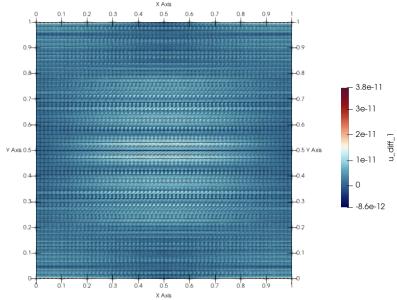
(b) $p = 1, 64 \times 64$



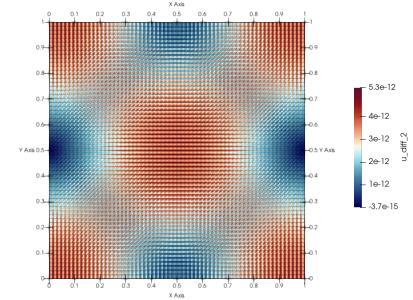
(c) $p = 2, 64 \times 64$



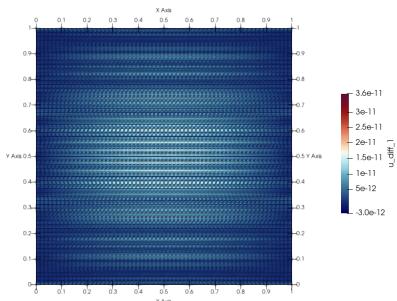
(d) $p = 2, 64 \times 64$



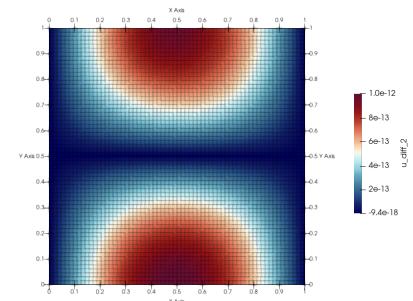
(e) $p = 3, 64 \times 64$



(f) $p = 3, 64 \times 64$



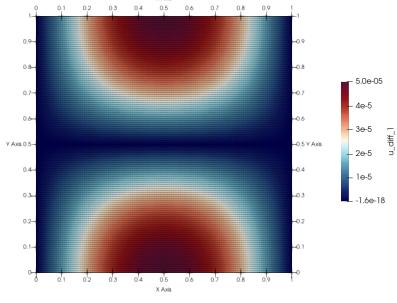
(g) $p = 4, 64 \times 64$



(h) $p = 4, 64 \times 64$

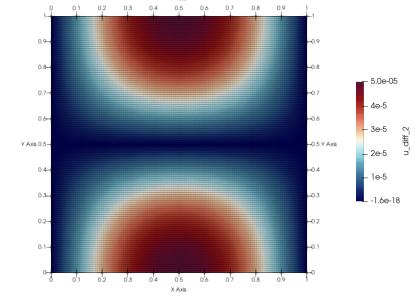
Figure 9: Comparison of numerical error for Method 1 and Method 2 for mesh resolutions of 64×64 and different polynomial orders ($p = 1$ to $p = 4$).

Method 1 Errors

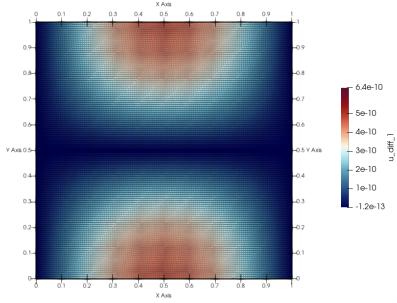


(a) $p = 1, 128 \times 128$

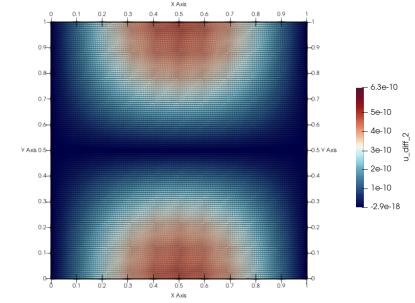
Method 2 Errors



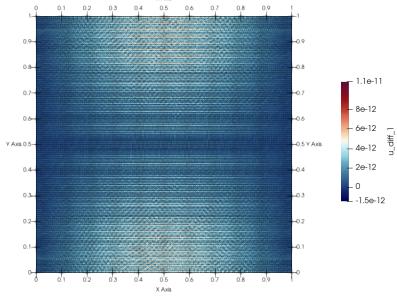
(b) $p = 1, 128 \times 128$



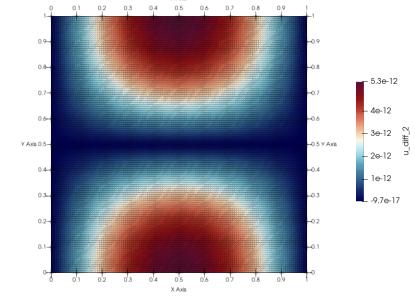
(c) $p = 2, 128 \times 128$



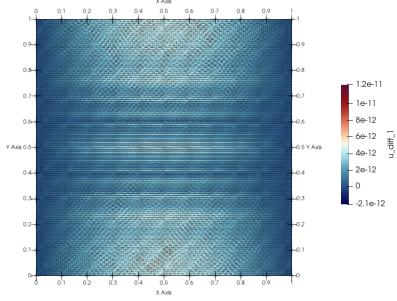
(d) $p = 2, 128 \times 128$



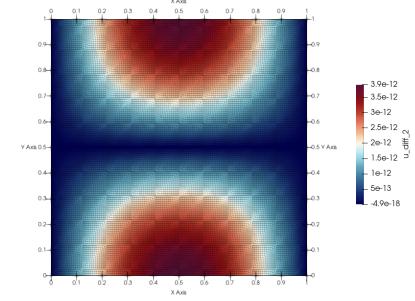
(e) $p = 3, 128 \times 128$



(f) $p = 3, 128 \times 128$



(g) $p = 4, 128 \times 128$



(h) $p = 4, 128 \times 128$

Figure 10: Comparison of numerical error for Method 1 and Method 2 for mesh resolutions of 128×128 and different polynomial orders ($p = 1$ to $p = 4$).