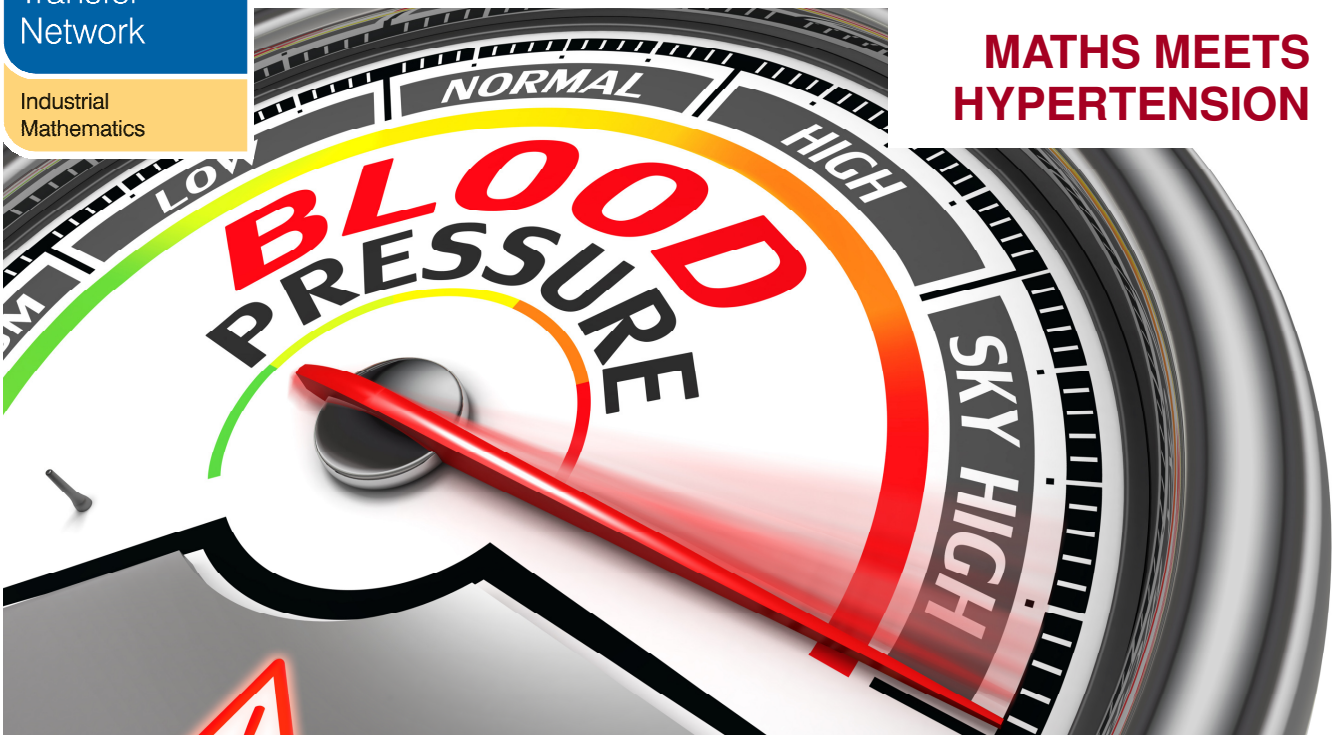
Knowledge Transfer Network

Industrial Mathematics

Technology Strategy Board
Driving Innovation

MATHS MEETS HYPERTENSION



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High blood pressure is a primary risk factor for premature death worldwide, currently costing the NHS over £1bn a year in medication alone. Its causes are still unclear, but the answer might be in the smallest blood vessels: capillaries. Individuals with high blood pressure have a reduced capillary density. This may initiate, and amplify hypertension. Therefore, the study of how capillaries become blocked and non-functional might be the key to breaking the onset of hypertension.

This is where mathematics can help spectacularly, providing an accurate, non-invasive method to reveal the elements which control the microcirculation. The challenge is that microscopically blood is not a continuum, so usual fluid dynamics stop being valid. Molecular dynamics on the other hand, becomes computationally unaffordable at this scale. To handle this type of problem, a new method in between the above extremes is now being developed: Multi-particle collision dynamics (MPC).

MPC considers the fluid as a set of particles. Additionally red blood cell membranes are modelled as particles which interact though elastic forces and repulsive potentials. Particles move by alternating steps: *stream* and *collide*. Particles are first allowed to move without interacting (stream). Then the system is divided into blocks and particles interact only with their neighbours (collide). This algorithm reproduces the macroscopic behaviour, accounting for the red blood cell deformations that determine capillary blood flow. A mathematical approach with MPC has the potential to discover new indicators for early diagnosis, and pave the way for understanding how hypertension develops and could be reversed.

The use of mathematics has profound consequences in all walks of life, but the opportunities that it opens up often go unrecognised or underexploited. The Industrial Mathematics KTN, enabled by the generous sponsorship of six leading corporate partners, ran the third annual TakeAIM competition in 2013 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to all undergraduate and postgraduate students working in the mathematical sciences. Authors of the best two entries each received a MacBook Air as their prize, with additional prizes being awarded to two runners-up.