Experimental Computation and Visual Theorems

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Abstract. Long before current graphic, visualisation and geometric tools were available, John E. Littlewood (1885-1977) wrote in his delightful *Miscellany*[1]:

> A heavy warning used to be given [by lecturers] that pictures are not rigorous; this has never had its bluff called and has permanently frightened its victims into playing for safety. Some pictures, of course, are not rigorous, but I should say most are (and I use them whenever possible myself). [p. 53]

Over the past five to ten years, the role of visual computing in my own research has expanded dramatically. In part this was made possible by the increasing speed and storage capabilities—and the growing ease of programming—of modern multi-core computing environments. But, at least as much, it has been driven by my group's paying more active attention to the possibilities for graphing, animating or simulating most mathematical research activities.

I shall first briefly discuss what I mean by *visual theorems*, by *experimental computation*, and by *digital assistance*. I then turn to *dynamic geometry* (iterative reflection methods [1]) and *matrix completion problems*[2] (applied to protein conformation [3]). I end with description of recent work from my group in *probability* (behaviour of short random walks [6, 8]) and *transcendental number theory* (normality of real numbers [2]).

As I discuss these topics—some of which will be revisited in presentations by Bailey, Straub, Tam and others—I also intend to flag issues for the rest of the workshop.

Keywords: visual theorems, experimental mathematics, digital assistance, protein conformation, symbolic-numeric and graphic computing, numerical analysis, randomness, normality of numbers, short walks, planar walks, fractals.

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[1] J.E. Littlewood, *A mathematician's miscellany*, London: Methuen (1953); J. E. Littlewood and Béla Bollobás, ed., *Littlewood's miscellany*, Cambridge University Press, 1986.

[2] See http://www.carma.newcastle.edu.au/jon/Completion.pdf and http://www.carma.newcastle.edu.au/jon   ields11.pptx.