Unmanned Aerial Vehicles (Drones) in Archaeology - a Help or Hindrance?

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ABSTRACT

It's true to say that technology has a part to play in all modern aspects of life and therefore represents a significant vehicle for inter-disciplinary activities. This paper reviews some personal experiences as a Computer Scientist in terms of collaborative opportunities in research, education and industry. Consideration is given towards how novel technologies can provide a gateway to the promotion of shared interest and examines some recent proposals for joint work with the department of Archaeology at Queen's University Belfast in utilising drones for data collection and analysis.

Keywords: Computer Science, Student Recruitment, Novel Technologies, Drones.

1. INTRODUCTION

The title of this paper is (kind of) a misnomer. This work certainly addresses some interesting aspects of research involving unmanned aerial devices (UAV drones) together with associated applications. However, the question posed in the title alludes to the importance of effectively representing research areas, particularly with regard to student recruitment. This work considers the issues of student recruitment in the context of previous research in the area of multiprocessor systems and current activities in drone software development.

Over a period spanning more than two decades, much of our work has involved engineering software systems for science and engineering applications, typically utilising complex, high-performance, multi-processor architectures[1,2,3]. While this has yielded interesting pathways for scientific exploration, project success (to some extent) has usually relied on attracting suitable research students. However, given the significant mathematical context of the work, making the work appealing enough to stand out in a competitive student recruitment market is a significant challenge.

Figure 1: Alternative Paper Title

Little needs said on the importance of eye catching ideas for advertising a concept. One case in point is the attention-grabbing play on words, as a novel alternative title for this paper (figure 1), with (fair use) homage to the Game of Thrones franchise. The intention here is to focus the eye and the mind on the potential for what lies ahead.

In a similar context, the utilization of novel computation technologies, integral to project specification, has proved to be very effective in attracting student applications. This paper examines two instances of this approach to project recruitment, providing novelty, not just in title, but also in research content and how this can enhance exposure for the associated work and make it easier for students to more effectively communicate their ideas.

2. A THRIFTY APPROACH TO HIGH PERFORMANCE COMPUTING

Initial consideration for the deployment of novel computing technologies stemmed from our work in porting existing (sequential) mathematical codes to multiprocessor architectures. This work (significantly) made early use of artificial intelligence (AI) techniques in this process, to replicate the experience of the human programmer. In this sense, sequential programming tasks are partitioned (under system guidance) and mapped to target multiprocessor platforms with aims for enhanced performance (figure 2).

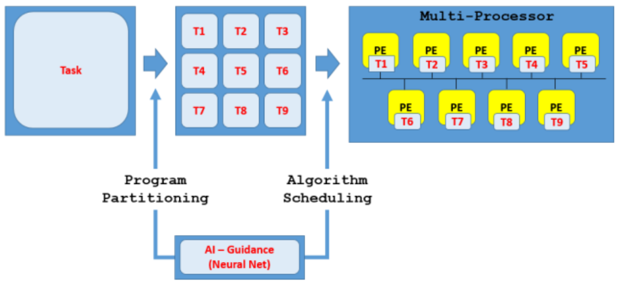

Figure 2: AI Support for Sequential Code Acceleration

Using Novel Technologies in a Research Context

While much of the work utilized expensive equipment with recognizable names such as Cray, cheaper alternatives were also considered to enhance the scalability, appeal and novelty of the work. To this end, one such initiative sought to explore the use of popular consumer games platforms such as the Sony PS3 [4] as potential target architectures for the work.

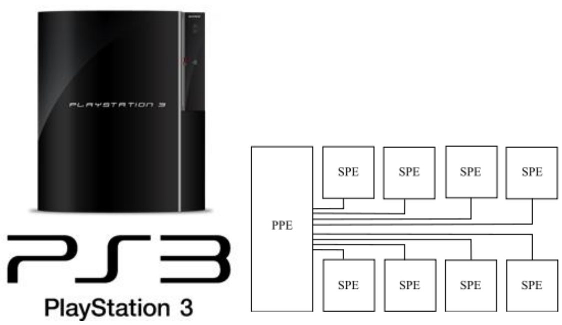

Figure 3: Cell BE Processor Structure

This device presented a viable target architecture as it was based on the Cell BE processor offering one PPE (Power Processing Element) core together with eight SPE (Synergistic Processing Element) cores. Furthermore, networked clusters of these machines could be configured at a fraction of the cost comparable platforms.

The Computational Problem: Slater Integrals

The chosen application involved the restructuring of sequential codes for the computation of Slater integrals, targeted at the Sony PS3 platform, which involved the construction of Hamiltonian matrices [5] with the computation of up to 300 x 106 Slater integrals.

Slater integrals are two dimensional radial integrals whose integrand is constructed from normalized eigen-functions of the Schrodinger equation. Since computation of each Slater integral is data independent, this represents a good candidate for execution on a multiprocessor architecture.

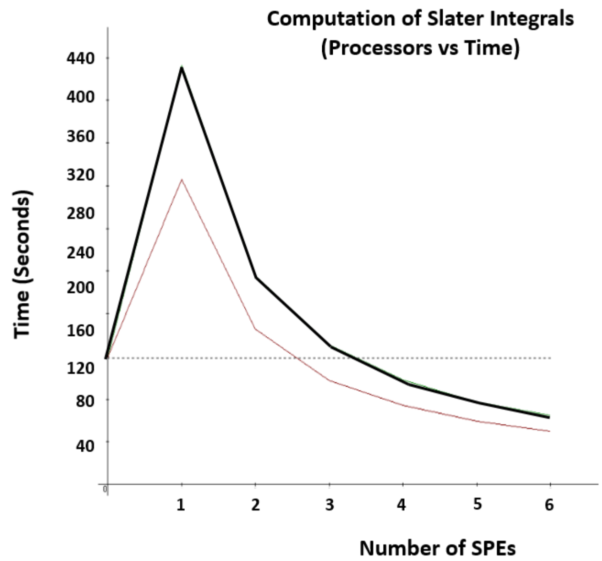

Figure 4: Version 1 Results

Version 1: PPE Centric

This implementation was based on a PPE-centric model where the main application runs on the PPE, with work offloaded to SPEs, with the PPE coordinating results returned by SPEs. The main code structure was mapped to the PPE and responsible for constructing the Hamiltonian matrix.

Calculation of each point required one or more integral computations, which were offloaded to the SPEs. Code for integral calculation was implemented in C and replicated across all SPEs. It was the role of the PPE to schedule integral calculations and collect results.

The initial configuration in this context involved no SPE vectorization and did indicate some performance improvement. However, some issue over data management and PPE/SPE synchronization were exposed (figure 4).

Version 2: SPE Centric

To address issues of poor performance, a SPE-centric implementation was developed whereby most of the application code was devolved to the SPEs with the PPE acting as a centralized resource manager. In this sense, more of the computation was devolved to the SPEs. The main role of the PPE here was to partition the Hamiltonian matrix allocating a share of the problem space to each SPE. For each point, an SPE calculates its own parameters (based on matrix point), fetches the necessary data and performs the related integration computation, significantly reducing scheduling overhead (figure 5).

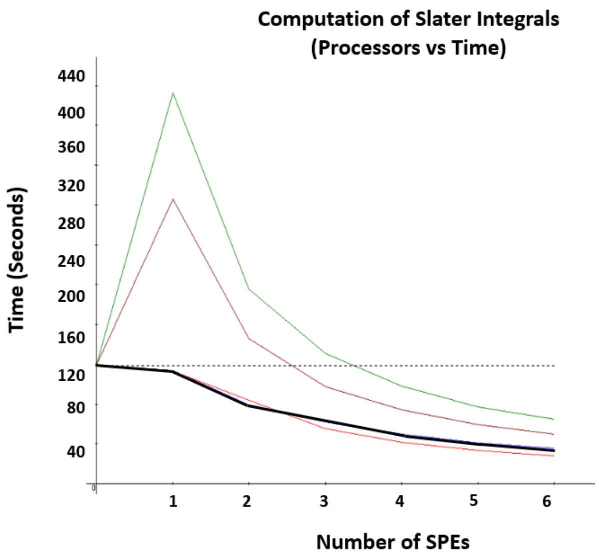

Figure 5: Version 2 Results

Again there was no SPE Vectorization for this configuration and there was a reduced need for PPE/SPE synchronization. The SPE tags results and directs memory accesses (DMAs) directly back to main memory. However, load on each SPE is not necessarily balanced.

Reflection on Impact
In terms of research results, the capacity for the PS3 as a viable computational platform was demonstrated, with significant implications for low cost and rapid deployment overhead. The novelty of the approach raised the profile of the work but, most importantly, inspired students to consider this type of research.
Demonstrations of the work, simply because of its association with the Sony Playstation 3, attracted significant attention when presented and performed admirably as an effective 'recruiting sergeant', appealing directly to the PlayStation generation.

3. UNMANNED AERIAL DRONES (UAVS)

The use of drones or unmanned aerial devices (UAVs) for survey purposes has increased significantly over the past few years with availability of relatively cheap (yet powerful) devices from manufacturers such as DJI [6]. Moreover, the availability of software application programming interfaces (APIs) enables third-party development of software with direct access to sensory and management functionality of these devices, thereby exposing a relatively new computational platform for research purposes.

Archaeologists [7] rely significantly on the utilization of these devices to provide multi-modal survey data, but are largely limited by the software provided. This, coupled with the facility to produce bespoke applications, has created a number of possibilities for joint explorative work between Computer Science and Archaeology. Two such areas are currently under consideration: intelligent flight planning and live, cloud-based image processing of data collected in the field.

Flight Planning
Drones may be managed in flight in two modes: under direct pilot control or under autonomous control [8]. For the latter, a flight plan is produced in advance of a flight and executed by a flight management system. A given flight plan will typically guide a drone along a sequence of points (as defined by GPS coordinates), governed by a specified height to take overhead images at each position, before returning to a point of origin (see figure 5).

Figure 5: An Example Flight Plan

For archaeological applications, such a plan would be constructed to include the required coverage of a land mass under survey. Areas of interest vary from looking for evidence of historical building activity to examining the range of predominant plant life and its extent. Flight plan control data is generated via a software application, with an initial aim of allowing the used to specify coverage using an interactive map while taking into consideration, device capabilities such as battery life and camera resolution together with prevailing wind speed and direction.

Figure 6: Detection of Ground-Based Features

Live Data Feature Detection
The aim of this drone project is to capture live telemetry and image data from a device in flight, and process this data using cloud-based computation resources to extract evidence of historical building features. The intention here is to overlay (in real time) potential building line markers on top of live image data (see figure 6).

Figure 6 shows a mock-up of the desired output for this approach, with oval structures detected and overlaid on live data, as indicators of historical man-made activity. The challenge here is to capture image data of sufficient quality to enable effective processing within the control application.

Reflections on Impact
While much of this work is currently at the proposal stage, a number of smaller 'feeder' projects have been proposed and advertised as suitable for undergraduate, final year projects in Computer Science.

Again, there is strong evidence to suggest that the novelty of the application area plays a significant part in student recruitment. In selecting projects, students are typically presented with a list of alternatives and are asked to select four or so in order of preference.

A single drone project was included in the list of potential projects and distributed to 100+ students. One would imagine, under normal circumstances a single project would become all but invisible among dozens of other possibilities.

However, the reality is very different in that several students made direct contact to gain further information, more than 10% included the project in their options list, with 4 top rankings, despite the overtly mathematical nature of the work.

4. CONCLUSIONS

To summarize, a good research project is a good research project but they can be enhanced by how they are presented to potential students. In both case studies described above, a conscious decision was taken to inject a novel approach in presenting project proposals. Both project areas are non-trivial in terms of required programming skills and mathematical ability. No attempt was made to hide this fact. Where in the past, the absence of platform novelty would still yield student interest, the number of potential applicants would be low, given the computational difficulty of the work. However, the use of novel application technologies as an integral part to project specification has directly led to increased interest from capable students who, in different circumstances, might have otherwise been dissuaded by complexity.

So, reflecting on the original title: "Drones in Archaeology – A Help or a Hindrance?", and generalizing to the use of novel technologies - their inclusion was certainly positive and yielded many points of discussion, not just on novelty but on the underlying research as a whole. This alone makes the approach worthwhile.

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