II. Brief Introduction of the Project

(*Involved field of science and technology, main research contents, discoveries, scientific value, citations and appraisals by other researchers in the same field*)

GPU, or Graphics Processing Unit, used to be designed purely for the graphics processing and rendering a decade ago. However today, computers with multiple GPU or large amount of GPUs become a powerful architecture capable of undertaking the task of general purpose computation, or even supercomputing. This is what is called GPGPU, or General Purpose Computation based on GPU. Along with the drastic progress of GPGPU development, people come to look it as one of the most significant events in the contemporary computing industry after the invention of PC & integrated circuits. The project reported here is just to show **a track or a step of contribution on this topic from Macau**, **made from the early stage of GPGPU development.**

By programming GPU for certain non-graphic computation from the early time this century, GPGPU starts to become a technical focus in discussion from 2003, typically at the ACM SIGGRAPH/Eurographics Graphics Hardware Workshop in 2003. A significant step forward in pushing the development of GPGPU came up at the Poster Workshop of GP^2 in the year 2004 at ACM SIGGRAPH2004. The historic workshop attracted 47 accepted submissions (see the list in Appendix I-1), among which only a small number of 9 works from outside of North American, 4 from Europe and 5 from Asia. Our work on the **Physical Simulation of Fluid Dynamics fully implemented on GPU** was one of the two from China, with the other from Chinese Univ. of HK on GPU based wavelet transformation. The difficulty in conducting GPGPU research in the early time came from the fact that the programming to GPU had to be at the very low level of the hardware, and the interface between the applications running by the high level tools & the programmable GPU working at the hardware level, makes a big barrier for harmonizing the both. Besides, the solution to the application problems might be quite comprehensive but the computation on the GPU for the stream processing often requests a substantial re-design to the application algorithms and programming. Therefore, the majority of the investigators at the early stage conducting GPGPU research are mainly from the core part of the GPU development area. This is the reason that at the GP^2 Workshop, more than one third of the works (17/47) were from UNC Chapel Hill & Stanford University, both respectively made substantial contribution in the history to the idea & structure of the GPU development, by a series of graphics processing machine from UNC (Pixel-Plane) for SIMD parallel processing & the Brooks stream

processing system and software development from Stanford University respectively.

Further improvement was made on fluid dynamics based on GPU in our project, a keynote paper & speech (see Appendix I-2 & paper 1) was invited at 17th CASA04 in Geneva, mainly on 2D fluid dynamics, then further at 12th Pacific Graphics04, our work on 3D dynamics was presented (paper 10). The 2 papers received extensive references from the papers at top-level journals and conferences. To sum up, this is our **first contribution: at the early GPGPU development stage, computation on fluid dynamics was fully designed & implemented on GPU, and in particular, efficient methods on GPU processing were proposed to handle arbitrary obstacles with complex boundary conditions in solving Navier-Stokes equations.** Computation in real time was able to be made for complex environments, with leading consequence achieved both in quality and efficiency. The work of the papers has been widely referenced by the papers at the major top journals and ACM conferences such as ACM Trans. on Graphics (TOG), IEEE Trans. on Visualization and Computer Graphics, IEEE Trans. on Medical Imaging, Proceeding of IEEE, ACM SIGGRAPH, Medical Image Analysis etc.

With regard to this work in China, a paper (paper 3) on the GPGPU development with our fist work was invited by the Chinese Journal of Software, a top Chinese journal in the computer field, originated from an invited honor presentation at the 15th anniversary of the journal(see Appendix I-3: the anniversary invited 6 presentations including the Turing Prize Laureate Andrew Yao & 3 CAS Academicians). Together with another paper at J. CADCG, (paper 4), both attracted hundreds of references in the area, and in fact they become the leading reference material for the people working on GPGPU in China.

The second contribution of the project is the **further successful extension of GPGPU to a few general application areas**, **including the simulation of soft-tissue deformation in medical imaging, the real time simulation of solid burning, physically based blur simulation in gaming** etc. In each of the works, we had proposed novel algorithms and methods to conduct the simulation, to transfer and optimize the computation to fit for the calculation on GPU, in taking advantage of the stream parallel processing of the GPU for the general computation in the applications.

Nobody is in doubt now, after its development in a decade, GPU has been and will be playing a powerful role in the general computation. By running this project from the initial stage of the GPGPU development, we have been in participation and witness the progress of the historic event. In successfully simulating the fluid dynamics fully on GPU, it has been further extended into some other general applications. Our works in particular on the

simulation of fluid dynamics, are well recognized worldwide and at home, by being invited to a few well notable conferences for Keynote Speech, such as, apart from 17th CASA04 in Geneva, the 6th Cyberwords2006 (EPFL in Lausanne, see Appendix I-4), 10th CAD/Graphics2007(Beijing, see Appendix I-5), and 17th ACM VRST2010(Hong Kong, see Appendix I-6). Particularly we like to introduce more about ACM VRST, the top forum on Virtual Reality for ACM, high reputation has been established for its professional fame & quality, with no more than 30% paper acceptance ratio including regular/short papers and posters. The conference has been in 3 times held in HK in this century (2002, 2004 & 2010), with in total 7 Keynote speeches invited, among which the PI of this project was the only one being invited twice (2002, 2010), and also the only person from Great China area.

To sum up, the significance of the project is, at the initial development stage of this historic event of GPGPU, we had made a single track, or lit an ignition from Macao, recognized by the people in the field.

(*Not exceed 1,200 words*)