

面向移动图形顶点处理器的高性能低功耗定点特殊函数运算单元设计

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High Performance and Low Power Fixed-point Special Function Unit for Mobile Vertex Processors

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摘要

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摘要 该文提出了一种应用于移动顶点处理器的高性能低功耗定点特殊函数运算单元电路。该运算单元支持嵌入式图形标准OpenGL ES 1.X的定点数据格式, 并支持小数点后16位精度的倒数、均方根、倒数均方根、对数和指数等初等函数运算。初等函数采用分段二次多项式插值方法近似计算, 系数处理中引入 $2^{-1/2}$ 运算电路, 相对于传统的设计在相同的精度下使整体的二次多项式查找表大小减少了29%。优化二次多项式插值算法的计算误差和截断误差, 使电路的查找表大小、平方器、乘法器和加法器的面积、速度达到最优。该电路采用0.18 μm 的CMOS工艺实现, 面积为0.112 mm^2 , 芯片时钟频率达到300 MHz, 功耗仅为12.8 mW。测试结果表明该定点特殊函数运算单元非常适合移动图形顶点处理器的初等函数计算应用。

关键词: 图形顶点处理器 计算机算法 初等函数 多项式近似 定点计算 特殊函数运算单元

Abstract: A high performance and low power fix-point Special Function Unit (SFU) for mobile vertex processors is presented in this paper. The system supports the fix-point format for OpenGL ES 1.X and implements 16 bit precision after the decimal point and faithfully rounded reciprocal, square root, reciprocal square root, logarithm, and exponential functions. The functions are approximated by using a piecewise quadratic interpolation technique. A square root 2 circuit is used in the unit, and the lookup table size is reduced by 29% with respect to previously proposed techniques, without any loss in accuracy. Based on analysis result of computer error and truncate error, the speed and area of lookup table, square unit, multiplier and fused accumulation tree reach optimal. The SFU has been implemented in a 0.18 μm CMOS technology. The circuit is able to operate up to 300 MHz clock frequency, with a power dissipation of 12.8 mW at 300 MHz and area only 0.112 mm^2 . The results show that the fixed-point SFU is ideal for mobile vertex processors computing elementary functions.

Keywords: Vertex processors Computer arithmetic Elementary functions Polynomial approximation Fixed-point computations Special Function Unit (SFU)

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