M4 DSP Matrix Functions

NuMicro® 32 位系列微控制器范例代码介绍

文件信息

代码简述	本范例代码使用M4内核DSP计算矩阵运算
BSP 版本	M480 Series BSP CMSIS V3.04.000
开发平台	NuMaker-PFM-M487 Ver 3.0

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1 功能介绍

1.1 简介

CMSIS DSP函式库有许多关于矩阵的运算包含：

1. 矩阵加法运算
2. 矩阵减法运算
3. 矩阵乘法运算
4. 逆矩阵
5. 矩阵缩放
6. 转置矩阵

在此范例程序使用CMSIS DSP函式库进行转置矩阵、矩阵乘法和反矩阵运算，用户可以直接使用这些函式，来实现自己的数学方程式运算。程序内比较了有无使用DSP计算时间的差异，并计算效率提升比率。

1.2 原理

用户须先用arm_matrix_instance_f32宣告矩阵变量，再来呼叫函式arm_mat_init_f32()对使用到的矩阵初始化设定，定义矩阵直行与横列个数以及矩阵数值。完成设定后即可对各矩阵进行运算，其程序设定如下表。

arm_mat_init_f32(arm_matrix_instance_f32 *S, uint16_t nRows, uint16_t nColumns, float32_t *pData)		
参数：	*S	[in, out] 指向所宣告的浮点数矩阵结构
	nRows	[in] 矩阵直行个数
	nColumns	[in] 矩阵横列个数
	*pData	[in] 矩阵数据
回传值：		无

arm_mat_add_f32(const arm_matrix_instance_f32 *pSrcA, const arm_matrix_instance_f32 *pSrcB, arm_matrix_instance_f32 *pDst)		
参数：	*pSrcA	[in] 输入被加数矩阵
	*pSrcB	[in] 输入加数矩阵
	*pDst	[out] 输出结果矩阵
回传值：		成功显示ARM_MATH_SUCCESS, 矩阵不相合则显示 ARM_MATH_SIZE_MISMATCH

arm_mat_sub_f32(const arm_matrix_instance_f32 *pSrcA, const arm_matrix_instance_f32 *pSrcB, arm_matrix_instance_f32 *pDst)		
参数：	*pSrcA	[in] 输入被减数矩阵
	*pSrcB	[in] 输入减数矩阵
	*pDst	[out] 输出结果矩阵
回传值：		成功显示ARM_MATH_SUCCESS, 矩阵不相合则显示 ARM_MATH_SIZE_MISMATCH

arm_mat_mult_f32(const arm_matrix_instance_f32 *pSrcA, const arm_matrix_instance_f32 *pSrcB, arm_matrix_instance_f32 *pDst)		
参数：	*pSrcA	[in] 输入被乘数矩阵
	*pSrcB	[in] 输入乘数矩阵
	*pDst	[out] 输出结果矩阵
回传值：		成功显示ARM_MATH_SUCCESS, 矩阵不相合则显示 ARM_MATH_SIZE_MISMATCH

arm_mat_inverse_f32(const arm_matrix_instance_f32 *pSrc, arm_matrix_instance_f32 *pDst)		
参数：	*pSrc	[in] 输入欲计算矩阵
	*pDst	[out] 输出逆矩阵
回传值：		成功显示ARM_MATH_SUCCESS, 矩阵不为方阵则显示ARM_MATH_SIZE_MISMATCH, 若矩阵不可逆显示ARM_MATH_SINGULAR

arm_mat_scale_f32(const arm_matrix_instance_f32 *pSrc, float32_t scale, arm_matrix_instance_f32 *pDst)		
参数：	*pSrc	[in] 输入欲计算矩阵
	scale	[in] 缩放参数
	*pDst	[out] 输出结果矩阵
回传值：		成功显示ARM_MATH_SUCCESS

arm_mat_trans_f32(const arm_matrix_instance_f32 *pSrc, arm_matrix_instance_f32 *pDst)

参数：	*pSrc	[in] 输入欲计算矩阵
	*pDst	[out] 输出转置后矩阵
回传值：		成功显示ARM_MATH_SUCCESS

1.3 执行结果

执行后会打印出以下信息

```
+----------------------------------------+
|     DSP Matrix functions Sample Code   |
+----------------------------------------+

Calculating time with DSP instruction is 0.040667 ms

Calculating time without DSP instruction is 0.243083 ms

Efficiency increase rate is 5.98
```

2 代码介绍

使用CMSIS DSP函数库进行转置矩阵、矩阵乘法和反矩阵运算：

```
/* Initialize A Matrix Instance with numRows, numCols and data array(A_f32) */
arm_mat_init_f32(&A, numRows, numCols, A_f32);

/* Initialize Matrix Instance AT with numRows, numCols and data array(AT_f32) */
arm_mat_init_f32(&AT, numRows, numCols, AT_f32);

/* calculation of A transpose with DSP instruction */
arm_mat_trans_f32(&A, &AT);

/* Initialize ATMA Matrix Instance with numRows, numCols and data array(ATMA_f32) */
arm_mat_init_f32(&ATMA, numRows, numCols, ATMA_f32);

/* calculation of AT Multiply with A with DSP instruction */
arm_mat_mult_f32(&AT, &A, &ATMA);

/* Initialize ATMAI Matrix Instance with numRows, numCols and data array(ATMAI_f32) */
arm_mat_init_f32(&ATMAI, numRows, numCols, ATMAI_f32);

/* calculation of Inverse ((Transpose(A) * A) with DSP instruction */
arm_mat_inverse_f32(&A, &ATMAI);
```

接着使用CPU进行相同的计算：

```
/* Matrix Inverse (number of rows) */
void MatrixInverse(int n)
{
    uint32_t i,j,k;
    double t;
    for(i=0; i<n; ++i) {
        for(j=0; j<n; ++j) {
            A1_f32[i][n+j] = 0;
        }
    }
    for(i=0; i<n; ++i) {
        A1_f32[i][n+i] = 1;
    }
    for(i=0; i<n; ++i) {
        if(A1_f32[i][i] == 0)
```

```
            for(j=i+1; j<n; ++j)
                if(A1_f32[j][i] != 0) {
                    for(k=i; k<n*2; ++k)
                        swap(&A1_f32[i][k], &A1_f32[j][k]);
                    break;
                }
        /* if Matrix inverse not exist*/
        if(A1_f32[i][i] == 0) break;

        t = A1_f32[i][i];
        for(k=i; k<n*2; ++k) {
            A1_f32[i][k] /= t;
        }
        for(j=0; j<n; ++j) {
            if(i != j && A1_f32[j][i] != 0) {
                double t = A1_f32[j][i];
                for(k=i; k<n*2; ++k) {
                    A1_f32[j][k] -= A1_f32[i][k] * t;
                }
            }
        }
    }
}
/* Matrix Transpose (number of rows, number of columns) */
void MatrixTranspose(int m, int n)
{
    uint32_t i, j;
    for(i=0; i<n; i++) {
        for(j=0; j<m; j++) {
            resultT[i][j] = A1_f32[j][i];
        }
    }
}
/* Matrix Multiplication (number of rows, number of columns) */
void MatrixMult(int m, int n, int p)
{
    uint32_t i, j, k;
    for(i=0; i<m; i++) {
        for(j=0; j<p; j++) {
            resultM[i][j] = 0;
            for(k=0; k<n; k++) {
```

```
                resultM[i][j] = resultM[i][j] + resultT[i][k] * A1_f32[k][j];
            }
        }
    }
}
```

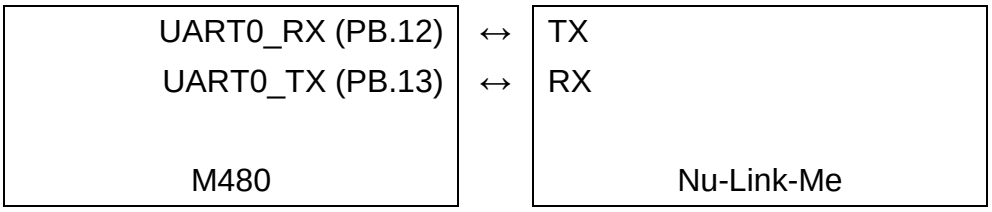
把计数器换成时间，其中计数器时钟源为HXT 12MHz：

```
/* Calculate the time, timer clock source is 12M, unit is ms */
DSPCalTime = (DSPCalTime/12000000) * 1000;
CalTime = (CalTime/12000000)* 1000;
```

3 软件与硬件环境

- 软件环境
  - BSP 版本
    - M480 Series BSP CMSIS V3.04.000
  - IDE 版本
    - Keil uVersion 5.26
- 硬件环境
  - 电路组件
    - NuMaker-PFM-M487 or other M480 Development Board
  - 示意图

M480 的 UART0_RX(PB.12)、UART0_TX(PB.13)连接至 Nu-Link Me，打印讯息。
设置终端机的 COM Port 与 Baud，COM Port 的编号可在设备管理器中找到「NuBridge Virtual Com Port (COMX)」，Baud 设置为 115200。



4 目录信息

- EC_M480_DSP_Matrix_V1.00
  - Library — Sample code header and source files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header file
    - StdDriver — All peripheral driver header and source files
  - SampleCode
    - ExampleCode — Source file of example code

5 如何执行范例程序

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 DSP_Matrix.uvproj
2. 进入编译模式接口
   a. 编译
   b. 下载代码至内存
   c. 进入 / 离开除错模式
3. 进入除错模式接口
   a. 执行代码

6 修订纪录

Date	Revision	Description
Jun. 25, 2019	1.00	1. 初始发布.

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