M4 DSP Convolution

Example Code Introduction for 32-bit NuMicro® Family

Information

Application	This sample code uses the M4 DSP to calculate Convolution
BSP Version	M480 Series BSP CMSIS V3.04.000
Hardware	NuMaker-PFM-M487 Ver 3.0

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1 Function Description

1.1 Introduction

This sample code uses the CMSIS DSP library to calculate Convolution, user can use these functions to implement mathematical equations. The sample code compares the difference between using the DSP calculation time and calculates the efficiency improvement ratio.

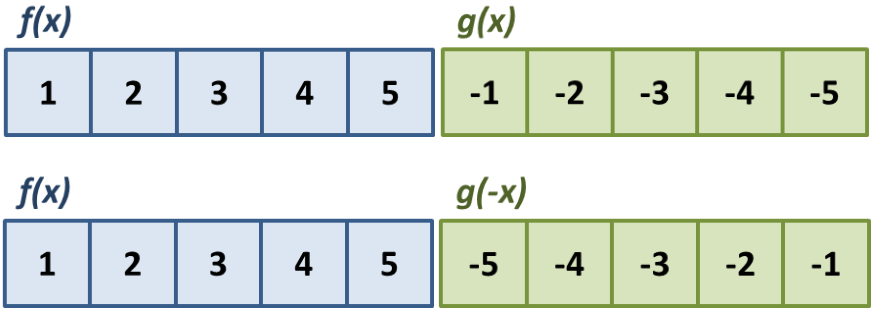
1.2 Principle

Convolution is a mathematical operation that operates on two finite length vectors to generate a finite length output vector. Convolution is similar to correlation and is frequently used in filtering and data analysis. The formula is defined as:

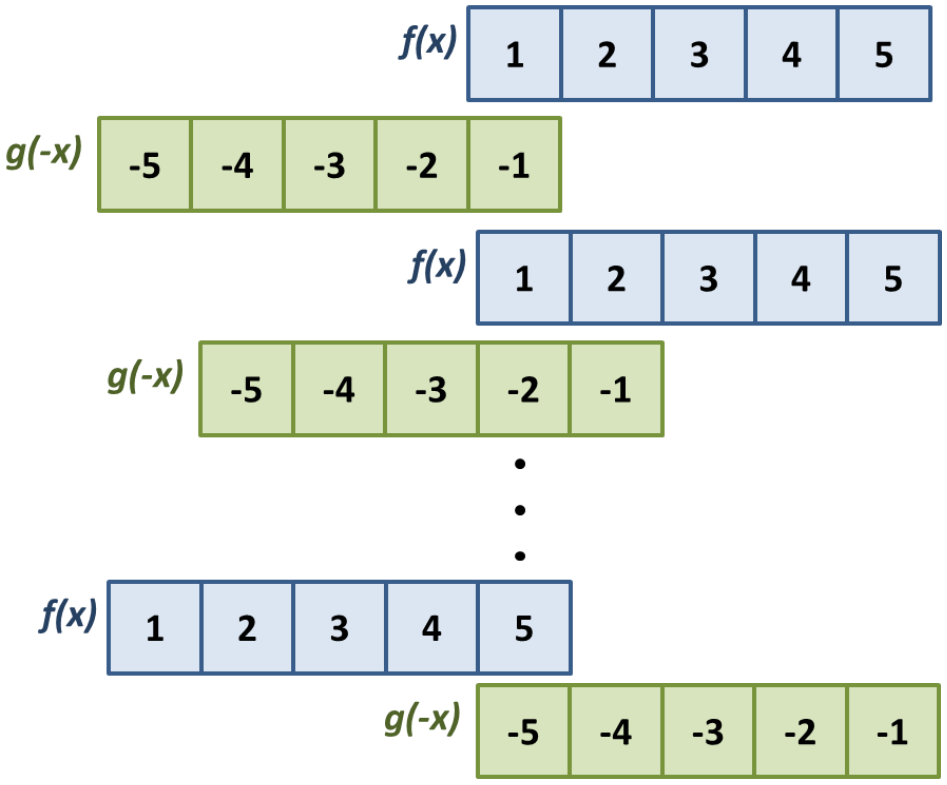
$$(f * g)(t) \stackrel{\text{def}}{=} \int f(\tau)g(t-\tau)d\tau$$

The following example diagram illustrates the calculation method and process:

1. Two finite length vectors *f(x)={1,2,3,4,5}*, *g(x)={-1,-2,-3,-4,-5}* and reflect one of the functions *g(x) -> g(-x)*:



2. Slide two vectors *f(x)* and *g(-x)*.Wherever the two functions intersect, find the integral of their product to generate third vector *h(x)*. Its calculation method is as follows：



h(1)=f(1)×g(1)= -1

h(2)=f(2)×g(1)+ f(1)×g(2)= -4

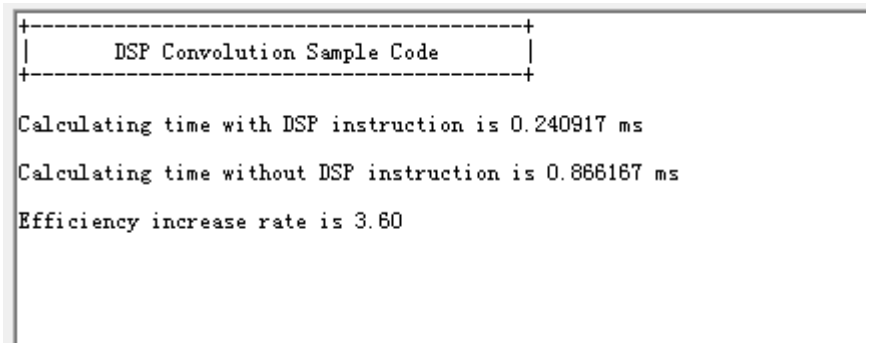
h(3)=f(3)×g(1)+ f(2)×g(2)+ f(1)×g(3)= -10

And so on, so get *h(x)={-1,-4,-10,-20,-35,-44,-46,-40,-25}*

In CMSIS DSP library, we can use `arm_conv_f32()` to calculate convolution. Its definition is as shown in Table：

`arm_conv_f32(float32_t *pSrcA, uint32_t srcALen, float32_t *pSrcB, uint32_t srcBLen, float32_t *pDst)`		
Parameters：	`*pSrcA`	[in] points to the first input sequence
	`srcALen`	[in] length of the first input sequence
	`*pSrcB`	[in] points to the second input sequence
	`srcBLen`	[in] length of the second input sequence
	`*pDst`	[out] points to the location where the output result is written. Length srcALen+srcBLen-1.
Returns：		none

1.3 Demo Result



2 Code Description

Use CMSIS DSP library to calculate convolution：

```
/* Calculate convoltion with M4 DSP instruction */
arm_conv_f32(testInput_f32_1kHz_15kHz, TEST_LENGTH_SAMPLES, firCoeffs32, NUM_TAPS,
conoutput);
```

And calculation convolution without DSP：

```
/* Convolution (length of the first input vector, length of the second input vector) */
void Convolution(int n,int m)
{
    CONLOutput = TEST_LENGTH_SAMPLES + NUM_TAPS - 1;
    for(i = 0; i < CONLOutput; ++i) {
        CONoutput[i] = 0;
    }
    for(i = 0; i < n; ++i) {
        for(j = 0; j < m; ++j) {
            CONoutput[i + j] += testInput_f32_1kHz_15kHz[i] * firCoeffs32[j];
        }
    }
}
```

Change the counter to time, where the timer clock source is HXT 12MHz：

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

3 Software and Hardware Environment

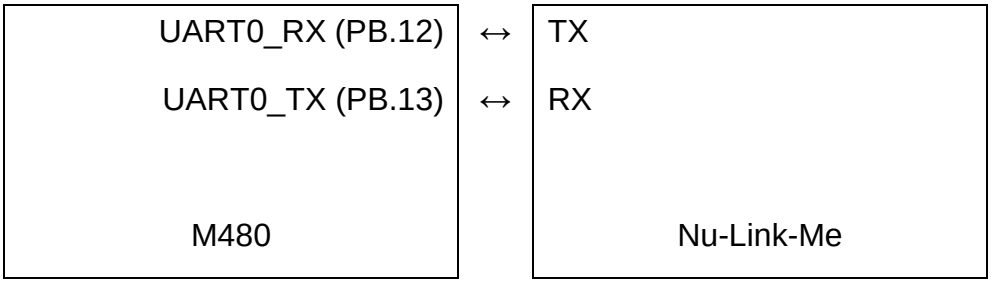
Software environment

- BSP version
  - M480 Series BSP CMSIS V3.04.000
- IDE version
  - Keil uVersion 5.26

Hardware environment

- Circuit components
  - NuMaker-IoT-M487 or other M480 Development Board
- Diagram

M480's UART0_RX (PB.12) and UART0_TX (PB.13) are connected to Nu-Link Me to print the message. Set COM port and Baud. The number of the COM Port can be found in the device manager "NuBridge Virtual Com Port (COMX)" and Baud is set to 115200.



4 Directory Information

- EC_M480_DSP_Convolution_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 How to Execute Example Code

1. Browsing into sample code folder by Directory Information (section 4) and double click DSP_Convolution.uvproj
2. Enter Keil compile mode
   a. Build
   b. Download
   c. Start/Stop debug session
3. Enter debug mode
   a. Run

6 Revision History

Date	Revision	Description
Jun. 21, 2019	1.00	1. Initially issued.

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