

# Arm® Mali™ RenderScript Best Practices

Version 1.0

## Developer Guide



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### Release Information

### Document History

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# Contents

## Arm® Mali™ RenderScript Best Practices Developer Guide

### **Preface**

<i>About this book</i> .....	6
<i>Feedback</i> .....	8

### **Chapter 1**

#### **Introduction**

1.1 <i>About RenderScript</i> .....	1-10
-------------------------------------	------

### **Chapter 2**

#### **RenderScript kernel best practices**

2.1 <i>Using global variables</i> .....	2-12
2.2 <i>Use allocation usage flags</i> .....	2-13
2.3 <i>Avoid casting user-defined data</i> .....	2-14
2.4 <i>Avoid recursive root functions</i> .....	2-15
2.5 <i>Use RenderScript intrinsic functions</i> .....	2-16
2.6 <i>Consider numerical precision</i> .....	2-17
2.7 <i>Debugging properties</i> .....	2-18

### **Appendix A**

#### **Revisions**

A.1 <i>Revisions</i> .....	Appx-A-20
----------------------------	-----------

# Preface

This preface introduces the *Arm® Mali™ RenderScript Best Practices Developer Guide*.

It contains the following:

- [About this book on page 6.](#)
- [Feedback on page 8.](#)

## About this book

This book describes the RenderScript best practices for Arm® Mali™ GPUs.

### Intended audience

This book is for developers working with RenderScript on Arm Mali™ Midgard or Bifrost GPUs. It is intended to be used in addition to Google RenderScript documentation, and provides Mali GPU-specific advice.

### Using this book

This book is organized into the following chapters:

#### **Chapter 1 Introduction**

This chapter introduces RenderScript.

#### **Chapter 2 RenderScript kernel best practices**

This chapter describes best practices and other performance considerations for RenderScript kernels.

#### **Appendix A Revisions**

This appendix describes the changes between released issues of this book.

### Glossary

The Arm® Glossary is a list of terms used in Arm documentation, together with definitions for those terms. The Arm Glossary does not contain terms that are industry standard unless the Arm meaning differs from the generally accepted meaning.

See the [Arm® Glossary](#) for more information.

### Typographic conventions

*italic*

Introduces special terminology, denotes cross-references, and citations.

**bold**

Highlights interface elements, such as menu names. Denotes signal names. Also used for terms in descriptive lists, where appropriate.

`monospace`

Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.

monospace

Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.

`monospace italic`

Denotes arguments to monospace text where the argument is to be replaced by a specific value.

`monospace bold`

Denotes language keywords when used outside example code.

<and>

Encloses replaceable terms for assembler syntax where they appear in code or code fragments. For example:

```
MRC p15, 0, <Rd>, <CRn>, <CRm>, <Opcode_2>
```

SMALL CAPITALS

Used in body text for a few terms that have specific technical meanings, that are defined in the *Arm® Glossary*. For example, IMPLEMENTATION DEFINED, IMPLEMENTATION SPECIFIC, UNKNOWN, and UNPREDICTABLE.

## Additional reading

This book contains information that is specific to this product. See the following documents for other relevant information.

### Arm publications

- *Arm® Mali™ Bifrost OpenCL Developer Guide* (ARM 101574).
- *Arm® Mali™ Midgard OpenCL Developer Guide* (ARM 100614).

See <https://developer.arm.com> for access to Arm documentation.

### Other publications

None

## Feedback

### Feedback on this product

If you have any comments or suggestions about this product, contact your supplier and give:

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# Chapter 1

## Introduction

This chapter introduces RenderScript.

It contains the following section:

- [1.1 About RenderScript on page 1-10.](#)

## 1.1 About RenderScript

RenderScript is a language and API in Android OS that enables you to use different processors for compute intensive tasks.

RenderScript applications can be written to make optimal use of the GPU acceleration capabilities offered by the Mali RenderScript GPU accelerator.

- For an overview of RenderScript, see <https://developer.android.com/guide/topics/renderscript/compute>.
- The RenderScript Java API is documented here <https://developer.android.com/reference/android/renderscript/RenderScript>.
- The RenderScript runtime API is documented here <https://developer.android.com/guide/topics/renderscript/reference/overview>.

# Chapter 2

## RenderScript kernel best practices

This chapter describes best practices and other performance considerations for RenderScript kernels.

It contains the following sections:

- *2.1 Using global variables on page 2-12.*
- *2.2 Use allocation usage flags on page 2-13.*
- *2.3 Avoid casting user-defined data on page 2-14.*
- *2.4 Avoid recursive root functions on page 2-15.*
- *2.5 Use RenderScript intrinsic functions on page 2-16.*
- *2.6 Consider numerical precision on page 2-17.*
- *2.7 Debugging properties on page 2-18.*

## 2.1 Using global variables

How to use global variables in RenderScript.

### Minimize the number and size of global variables used in your kernels

To enable hardware to accelerate global variables in root functions, the global variables are copied by the RenderScript runtime. The copy operations take time, so try to minimize them. Instead of using global variables, try passing all input to a root function with the input and output allocations. If you do this in invokable helper functions, it is unrestricted because the invokable functions always execute on the application processor.

Pack the data into one allocation. For example:

```
void root(const float2* in, float* out, uint32_t x)
{
    *out = in->x + in->y;
}
```

Avoid this type of construct:

```
rs_allocation array; //global allocation, same size as the input/output
void root(const float* in, float* out, uint32_t x)
{
    *out = *in + rsGetElementAt_float(array, x);
}
```

### Avoid writing to global variables

Writing to global variables within a kernel can degrade performance because it reduces the opportunity to apply performance optimizations. For example:

```
int global_var;
void root(const float* in, float* out)
{
    //reading from the global variable is ok
    int tmp = global_var;
    //avoid writing to the global variable.
    global_var = 1;
}
```

There is no restriction on using global variables in invokable helper functions. This is because invokable functions always execute on the application processor.

## 2.2 Use allocation usage flags

To ensure an allocation is supported on the GPU, include the `USAGE_SCRIPT` flag.

If an allocation does not have the `USAGE_SCRIPT` flag set, it is not supported on the GPU. If usage flags are not specified, an allocation is marked with `USAGE_SCRIPT` by default. However, an allocation might not have its `USAGE_SCRIPT` flag set, if it is explicitly marked with other flags. If a root function uses an unsupported allocation, it executes on the application processor.

If you are setting usage flags on an allocation, ensure that `USAGE_SCRIPT` is also added. The following example explicitly includes `USAGE_SCRIPT`:

```
Allocation.createTyped(
    mRS,
    typeBuilder.create(),
    MipmapControl.MIPMAP_NONE,
    //OR'd with USAGE_SCRIPT flag, acceleration enabled.
    Allocation.USAGE_GRAPHICS_TEXTURE | Allocation.USAGE_SCRIPT
);
```

The following example does not include `USAGE_SCRIPT` and is not usable on the GPU:

```
Allocation.createTyped(
    mRS,
    typeBuilder.create(),
    MipmapControl.MIPMAP_NONE,
    //Not marked with USAGE_SCRIPT, GPU acceleration disabled.
    Allocation.USAGE_GRAPHICS_TEXTURE
);
```

If the allocation is marked with `USAGE_IO_INPUT` or `USAGE_IO_OUTPUT`, the allocation is not supported on the GPU, even if you set `USAGE_SCRIPT`. For example:

```
Allocation.createTyped(
    mRS,
    typeBuilder.create(),
    MipmapControl.MIPMAP_NONE,
    //USAGE_IO_INPUT is not currently supported on the GPU, this allocation is CPU-only
    Allocation.USAGE_IO_INPUT | Allocation.USAGE_SCRIPT
);
```

## 2.3 Avoid casting user-defined data

Do not cast user-defined data to a different type, or reference data beyond the type referenced by the pointer.

Casting user-defined data to a different type, or reference data beyond the type referenced by the pointer, is not good practice, because it limits the scope of possible optimizations. For example:

```
typedef struct {
    int val;
} user_data_t;

void root(int * out, user_data_t * user)
{
    user_data_t * other_value = &(user[1]);
    *out = other_value->val;
}
```

## 2.4 Avoid recursive root functions

Do not implement root functions using direct or indirect recursion.

Recursive functions always execute on the application processor. They do not execute on the GPU.

## 2.5 Use RenderScript intrinsic functions

RenderScript intrinsic functions are high-performance implementations of functions.

The intrinsic functions outperform any equivalent function written in RenderScript.

Use the following intrinsic functions where possible to increase the performance of your application:

- `Blend()`
- `Blur()`
- `ColorMatrix()`
- `Convolve3x3()`
- `Convolve5x5()`
- `Histogram()`
- `LUT()`
- `YUVtoRGB()`

For more details on intrinsic functions, see <https://developer.android.com/reference/android/renderscript/ScriptIntrinsic>.



## 2.6 Consider numerical precision

The numerical precision of some built-in functions can vary across different functions.

The numerical precision of the following built-in functions can vary across different functions when they are accelerated on the GPU:

- `cospi()`
- `sinpi()`
- `tanpi()`
- `dot()`
- `mix()`

If your application is sensitive to numerical precision and uses one or more of these functions, test your script on different devices to ensure the range of results is within acceptable limits.

For more details on these built-in functions, see RenderScript runtime API documentation.

## 2.7 Debugging properties

RenderScript includes the `debug.rs.default-CPU-driver` and `debug.rs.script` debugging properties.

### **debug.rs.default-CPU-driver**

Values = 0 or 1

Default value = 0

If set to 1, the *Android Open Source Project* (AOSP) implementation of RenderScript Compute is used. This does not use any GPU features.

### **debug.rs.script**

Values = 0 or 1

Default value = 0

If set to 1, additional diagnostic information is printed in the logcat. This information includes the actual device a kernel is running on, either GPU or application processor.

If a kernel cannot be run on the GPU more detailed information is provided explaining why. For example:

```
[RS-DIAG] No support for recursive calls on GPU
```

# Appendix A

## Revisions

This appendix describes the changes between released issues of this book.

It contains the following section:

- [A.1 Revisions on page Appx-A-20.](#)

## A.1 Revisions

This appendix describes the technical changes between released issues of this book.

**Table A-1 Issue 0100\_00**

Change	Location	Affects
First release.	-	All