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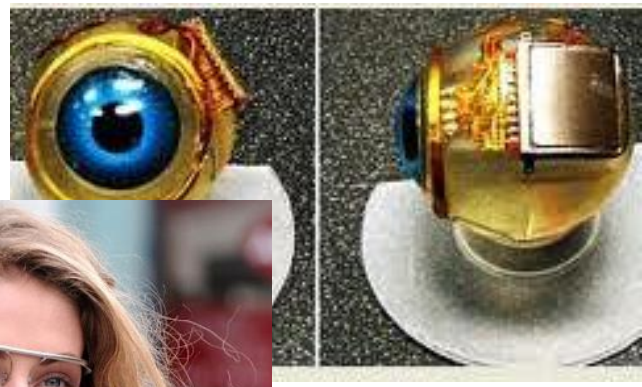
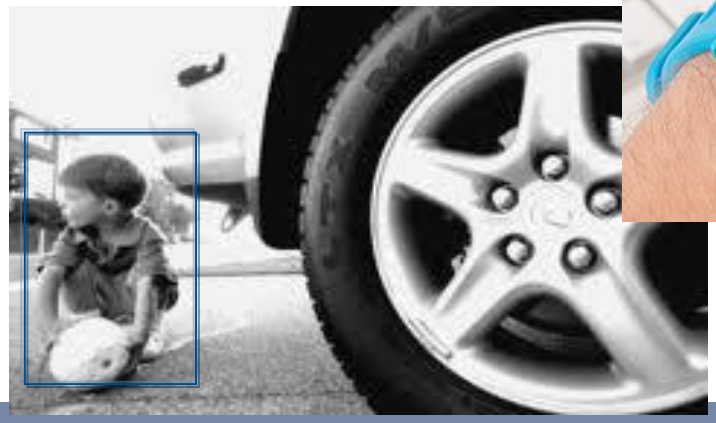
Innovating With Vision

Image Cognition Processing Technologies





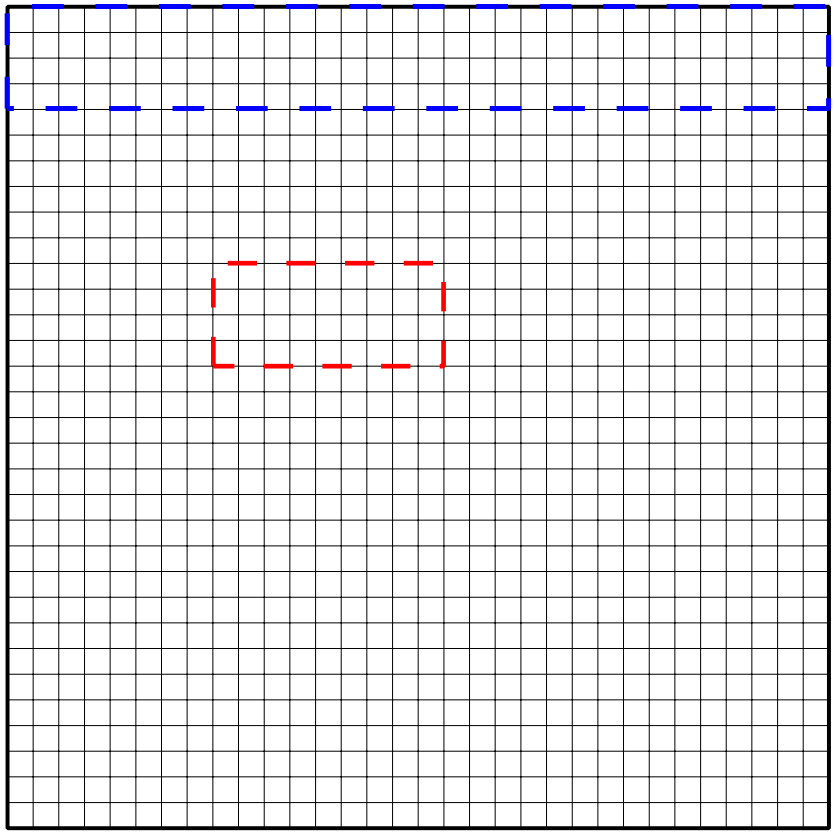
APEX Data Organization and Processing

2013 2014 Silicon 60 EE Times

2013 CIX TOP 20

Image processing

Let's start with an image. The first step is to split the image into slices. In this example, we'll use a slice of size 32x4. To process the slice, we must divide it into blocks. We will call these blocks "chunks" hereafter.



Slice processing

When splitting the slice into chunks, we need to end up with one chunk for each CU. In this example we'll be using 4 CUs. The width of each chunk is the width of the slice divided by the number of CUs, so here the chunk width will be 32/4 = 8. The chunk height is the same as the slice height. Therefore our chunk size will be 8x4.

The numbers in each box are the data values. Each red box represents a chunk.

00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F	30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F	70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F

Data organization in CMEM

The data for each chunk will be transferred into the memory of its corresponding CU.

00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F	30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F	70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F

CU_0 CU_1 CU_2 CU_3

The numbers in blue represent the CMEM addresses.

	CU_0	CU_1	CU_2	CU_3
A+00:	00	08	10	18
A+01:	01	09	11	19
A+02:	02	0A	12	1A
A+03:	03	0B	13	1B
A+04:	04	0C	14	1C
A+05:	05	0D	15	1D
A+06:	06	0E	16	1E
A+07:	07	0F	17	1F
A+08:	20	28	30	38
A+09:	21	29	31	39
A+22:	46	4E	56	5E
A+23:	47	4F	57	5F
A+24:	60	68	70	78
A+25:	61	69	71	79
A+26:	62	6A	72	7A
A+27:	63	6B	73	7B
A+28:	64	6C	74	7C
A+29:	65	6D	75	7D
A+30:	66	6E	76	7E
A+31:	67	6F	77	7F

Spatial dependency

In image processing, some algorithms have spatial dependencies. This means that when they're processing a section of the image, they need to have access to the data that surrounds it.

Ordinarily, a CU will only contain the data from the chunk that it's currently processing. However if we're dealing with an algorithm that has spatial dependencies, we use padding to ensure that the chunk has access to its surrounding data.

In the figure below, we can see how a spatial dependency of 1 pixel on each side maps out.

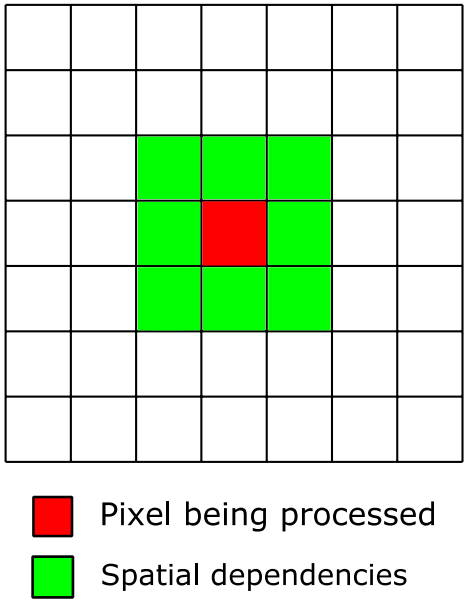
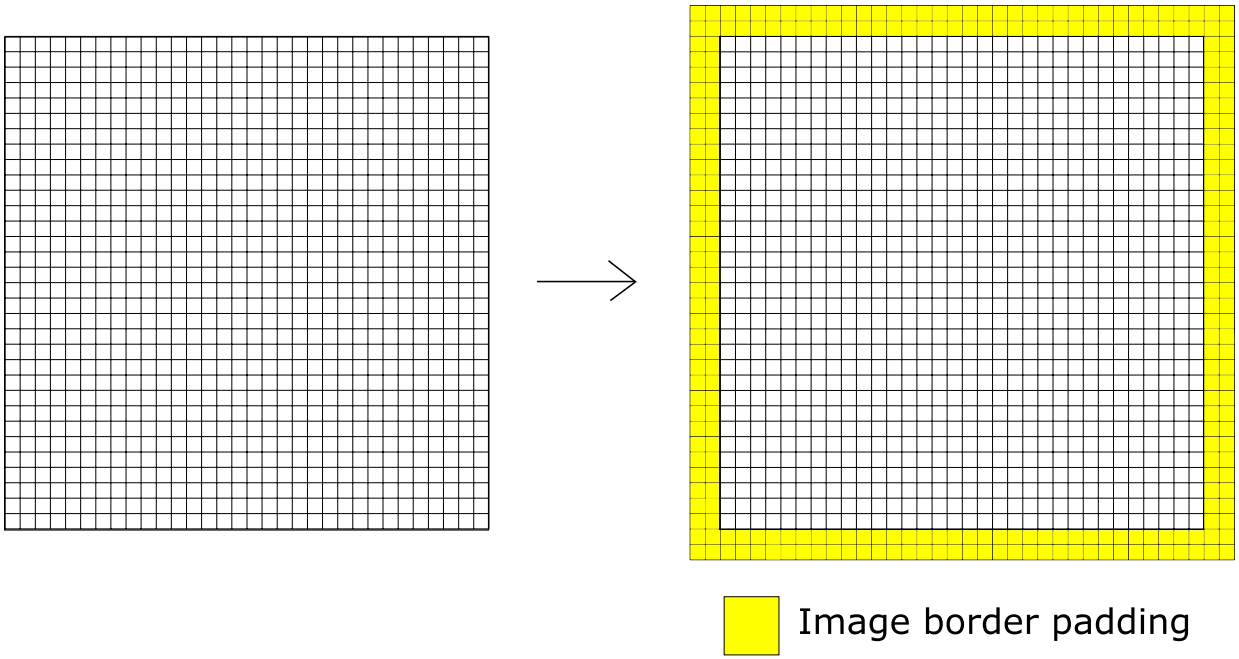


Image padding

Spatial dependencies add some requirements to properly process the image. The pixels that are on the edge of the image can't be processed because there is no data beyond the border. To solve this problem, we use image border padding that adds padding to the edge of the original image. The data beyond the edge might not exist, so it is often replicated from the edge values.

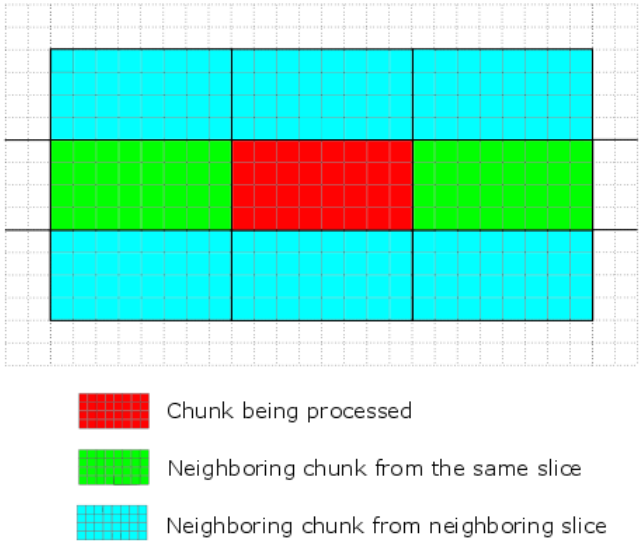


Chunk padding

With spatial dependencies, we encounter another problem when dealing with chunks: the kernel needs to have access to data from the neighboring chunks to process the pixels at the edge of the chunks. To do so, we perform chunk padding. Chunk padding reduces the complexity of kernel implementation and increases its reusability.

There are two types of chunk padding: vertical padding and horizontal padding.

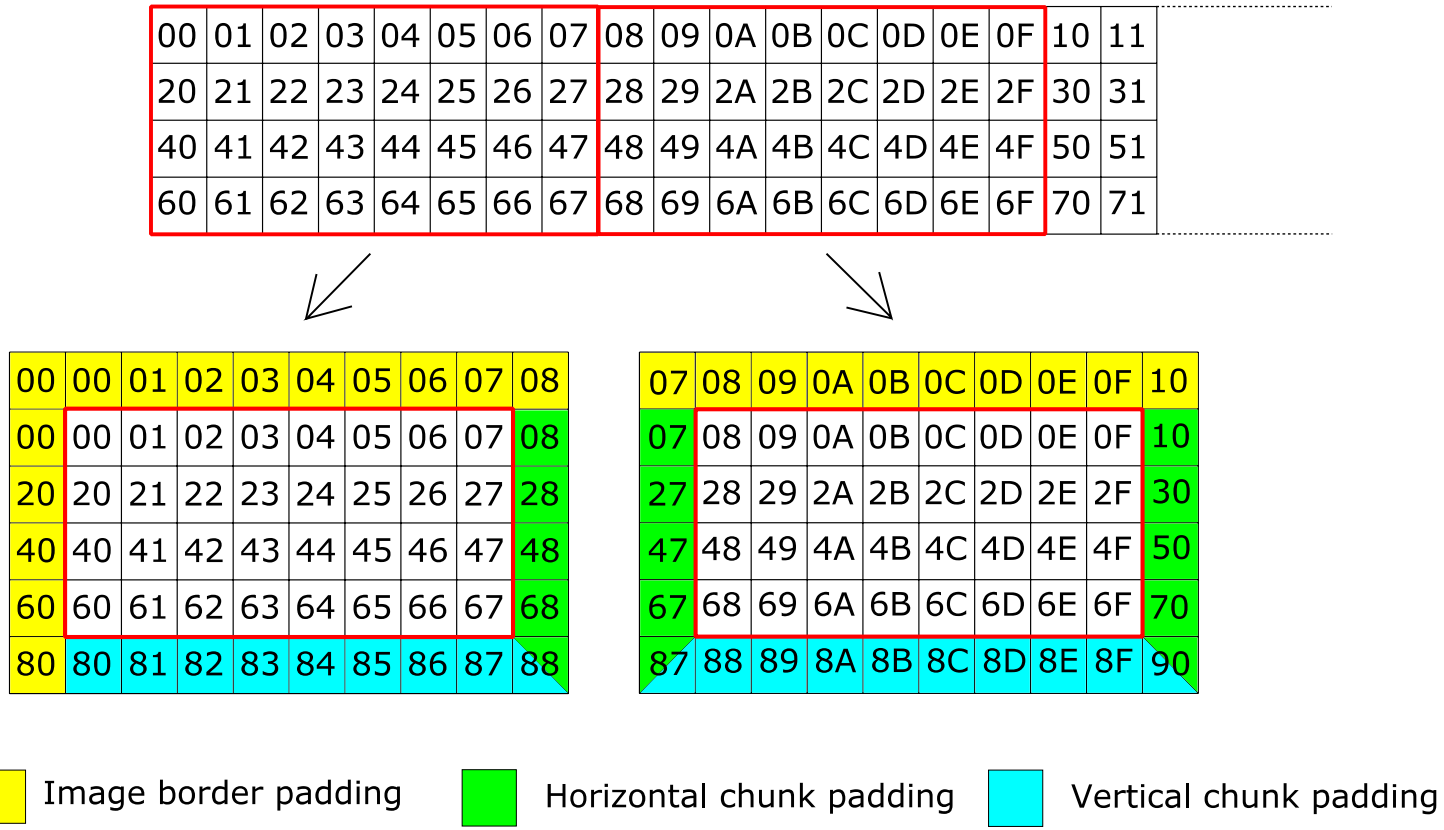
Vertical padding is used to access data that is above or below the chunk being processed. Since the chunk has a set height, that data will come from the chunk in neighboring slice that is either above or below the current slice.



Horizontal padding is used to access data that is to the left or right of the chunk being processed.

Chunk padding

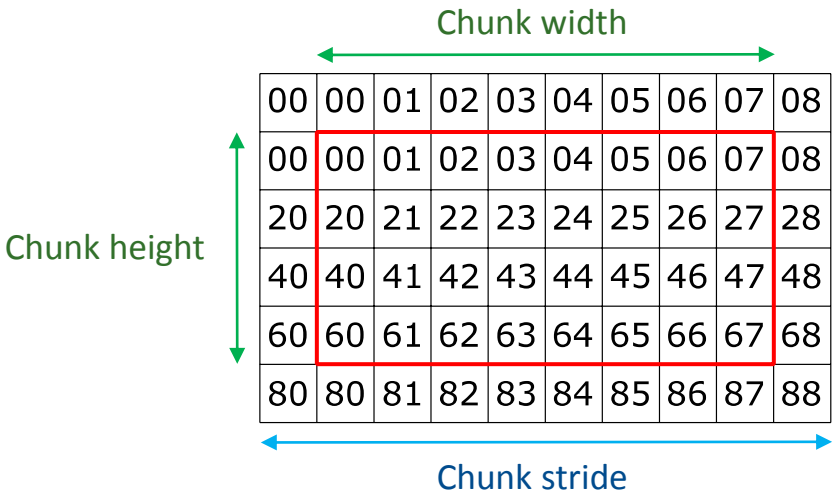
Let's go back to our slice example. This time we're going to assume that we have a spatial dependency of 1 pixel on each side. Since this is the topmost slice, we need to pad perform image border padding. We also need to perform chunk padding. Here is what it would look like:



Chunk stride

It is important to distinguish the ideas of chunk width and chunk stride when working with padded data. The chunk width is the number of values from the chunk that are currently being processed. The chunk stride is the total number of values that are placed in a single row. This means that the chunk stride includes the values from the current chunk, but also the values from the horizontal padding.

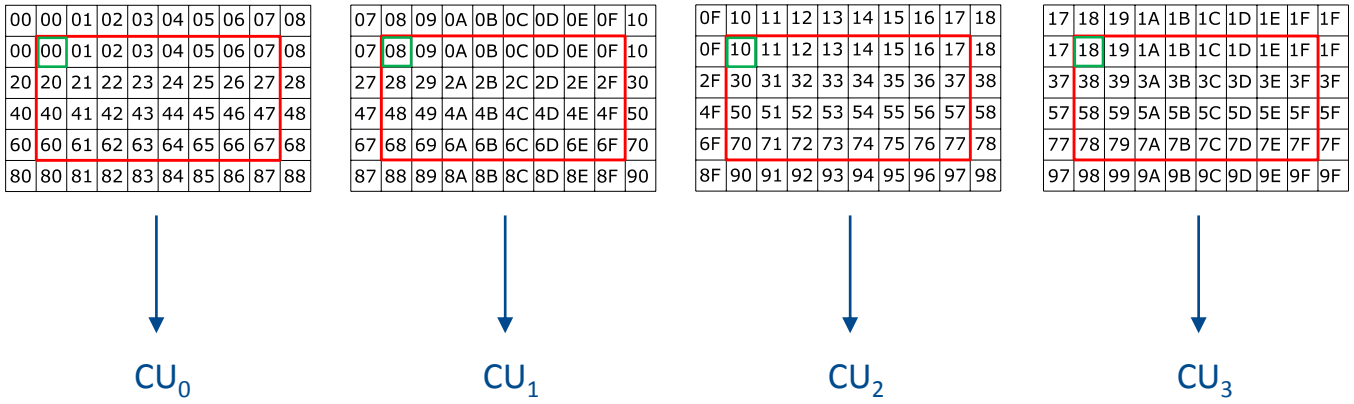
The chunk stride can be used to obtain the value in the same column but in the next row. If we add the chunk stride to the address of the current value, then we will obtain the address of the value beneath it.



In this example, the chunk size is 8x4, and there is a padding of 1 on each side. The chunk width is 8 and the chunk height is 4. Using the chunk width and the padding we can calculate the chunk stride: 1+8+1 = 10.

Chunk padding in CMEM

After the transfer, each CU contains the data from its corresponding chunk.
Note that chunk padding is automatically managed and provided by the APEX Core Framework.



	CU_0	CU_1	CU_2	CU_3
A -11:	00	07	0F	17
A -10:	00	08	10	18
A -09:	01	09	11	19
A -08:	02	0A	12	1A
A -07:	03	0B	13	1B
A -06:	04	0C	14	1C
A -05:	05	0D	15	1D
A -04:	06	0E	16	1E
A -03:	07	0F	17	1F
A -02:	08	10	18	1F
A -01:	00	07	0F	17
A+00:	00	08	10	18
A+01:	01	09	11	19
A+02:	02	0A	12	1A
A+36:	65	6D	75	7D
A+37:	66	6E	76	7E
A+38:	67	6F	77	7F
A+39:	68	70	78	7F
A+40:	80	87	8F	97
A+41:	80	88	90	98
A+42:	81	89	91	99
A+43:	82	8A	92	9A
A+44:	83	8B	93	9B
A+45:	84	8C	94	9C
A+46:	85	8D	95	9D
A+47:	86	8E	96	9E
A+48:	87	8F	97	9F
A+49:	88	90	98	9F

The numbers in blue represent the CMEM addresses.
Note that the base address (A) that gets passed into the kernel will be the pointing to the beginning of the chunk, not the beginning of the padding. It is marked in green.

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