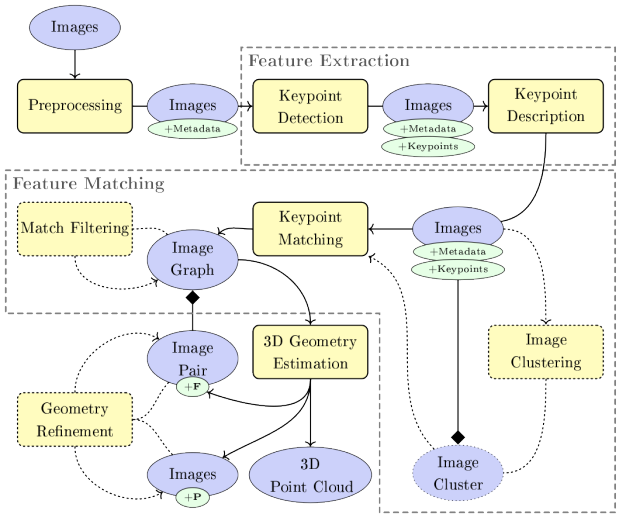
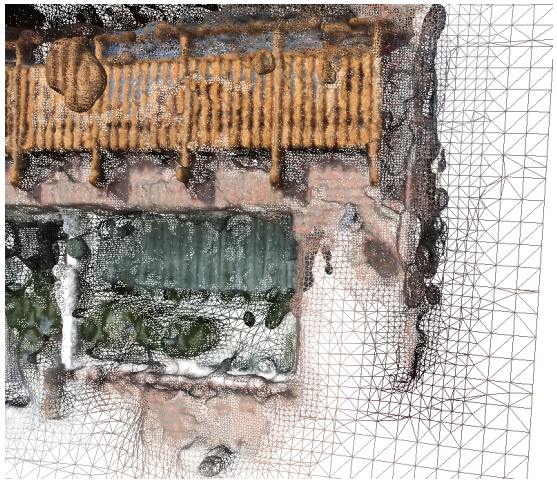
Master's thesis

A Modular Framework for Image-based 3D Reconstruction



Carsten Brandt

May 18, 2017



3D Reconstruction

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Structure from Motion (SfM)

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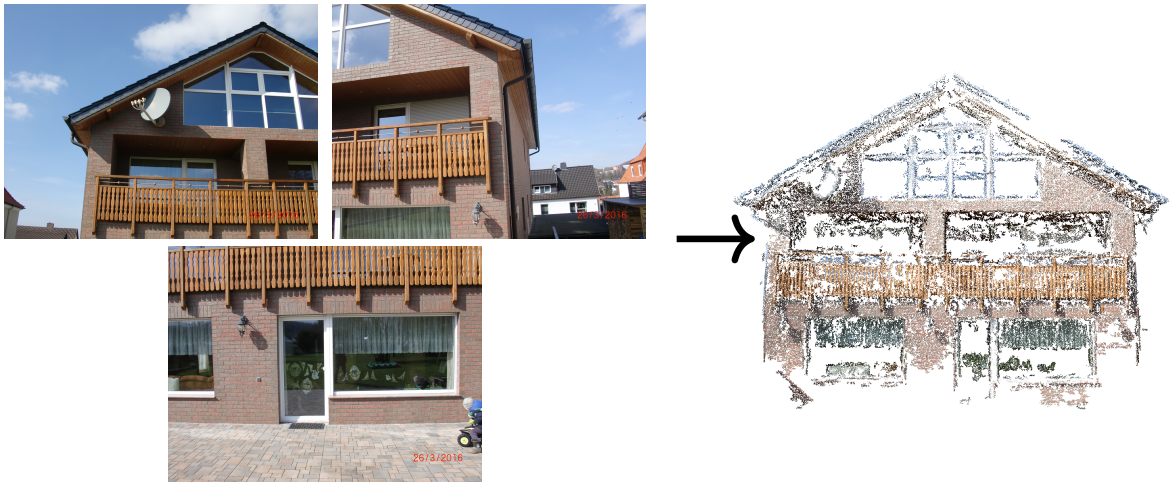
3D Reconstruction



Structure from Motion (SfM)

3D Reconstruction

Structure from Motion (SfM)

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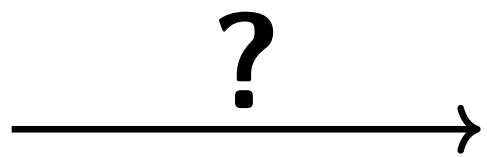

Problem Definition

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Keypoint Detection

Image Matching

Problem Definition

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Keypoint Detection

Image Matching

Geometry Estimation

Problem Definition

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Keypoint Detection

Image Matching

Geometry Estimation

Triangulation

Problem Definition

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Keypoint Detection

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Geometry Estimation

Triangulation

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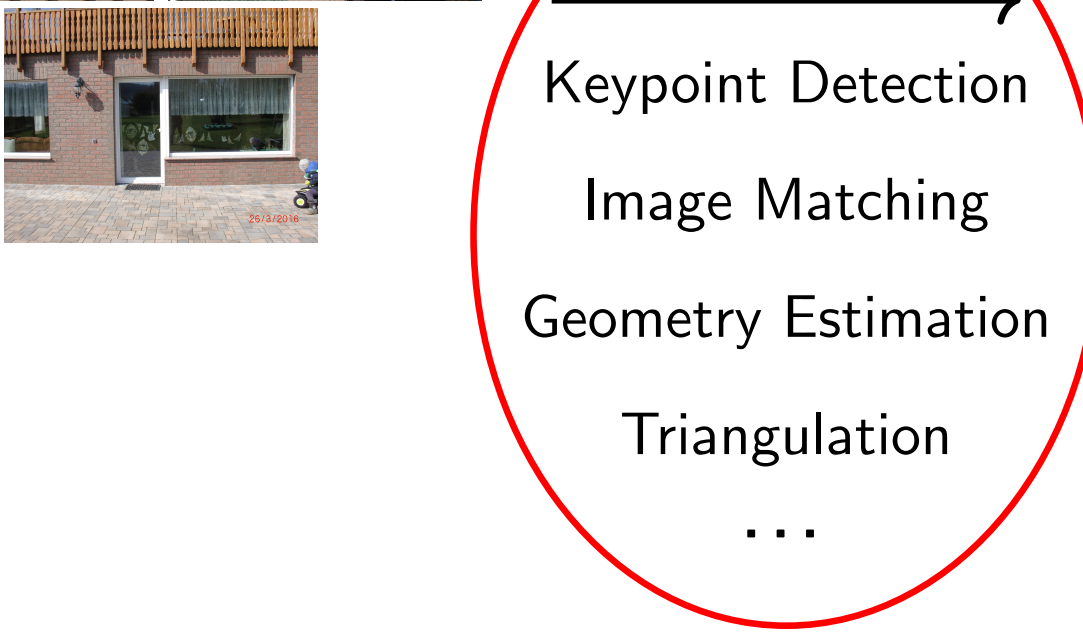
Problem Definition

Processing Chain



Existing implementations

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- single program for everything

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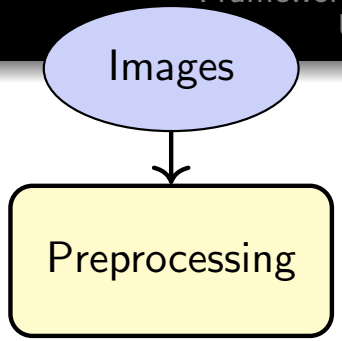
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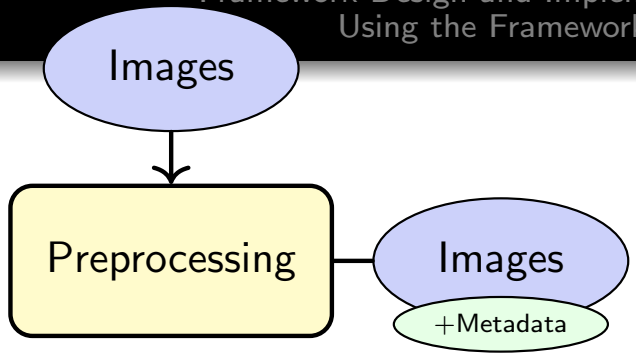
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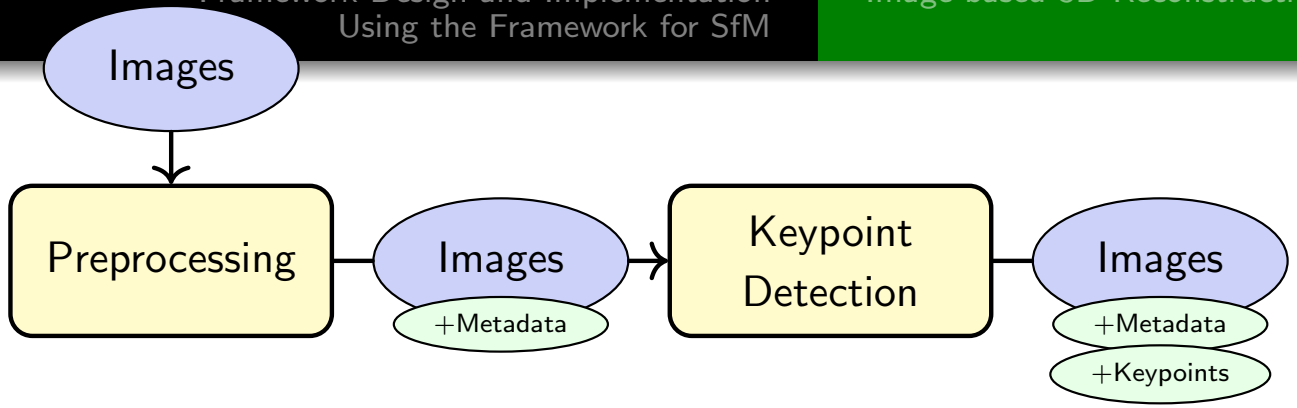
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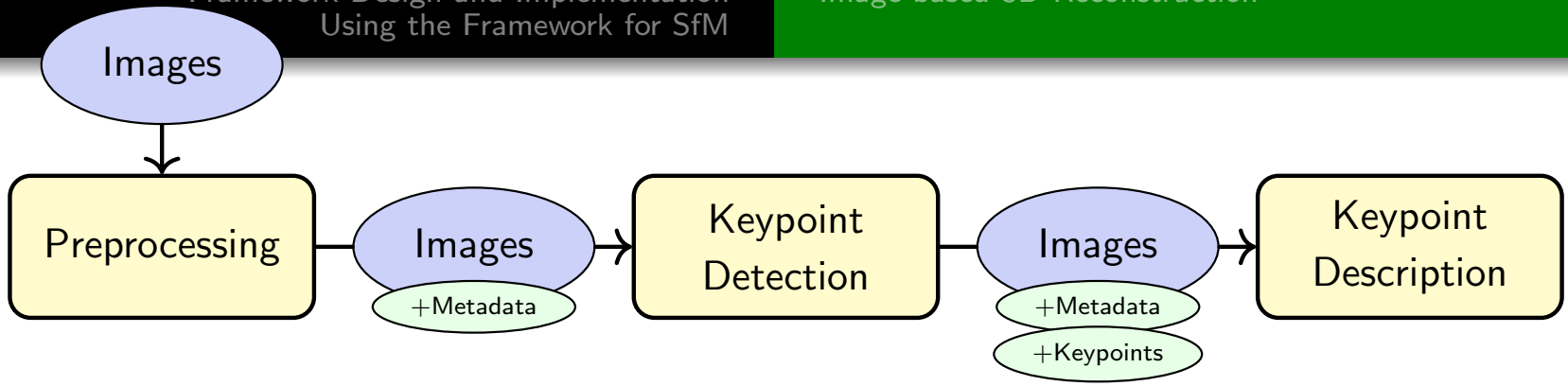
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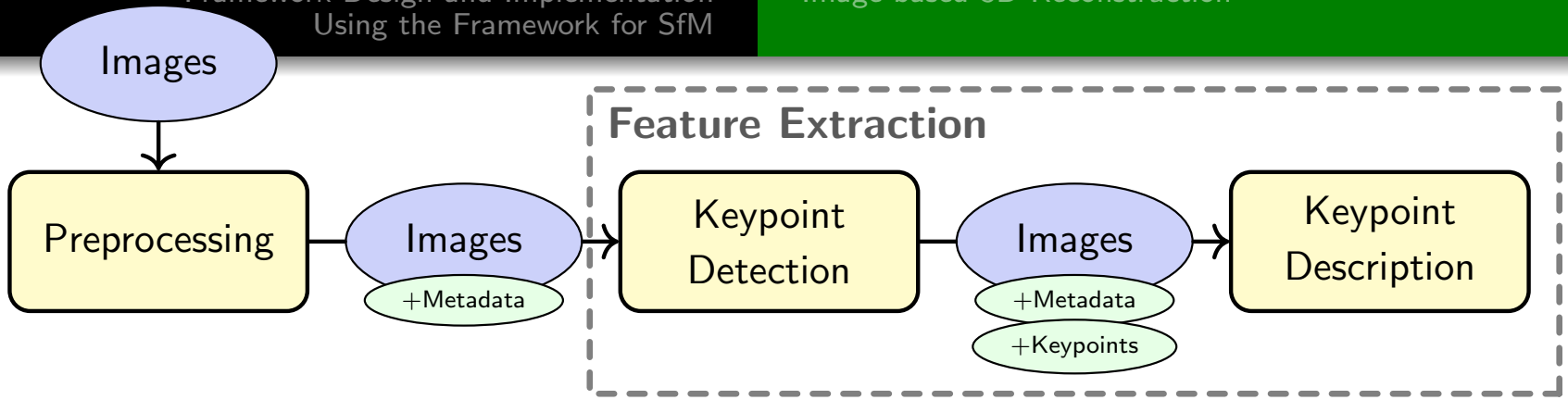
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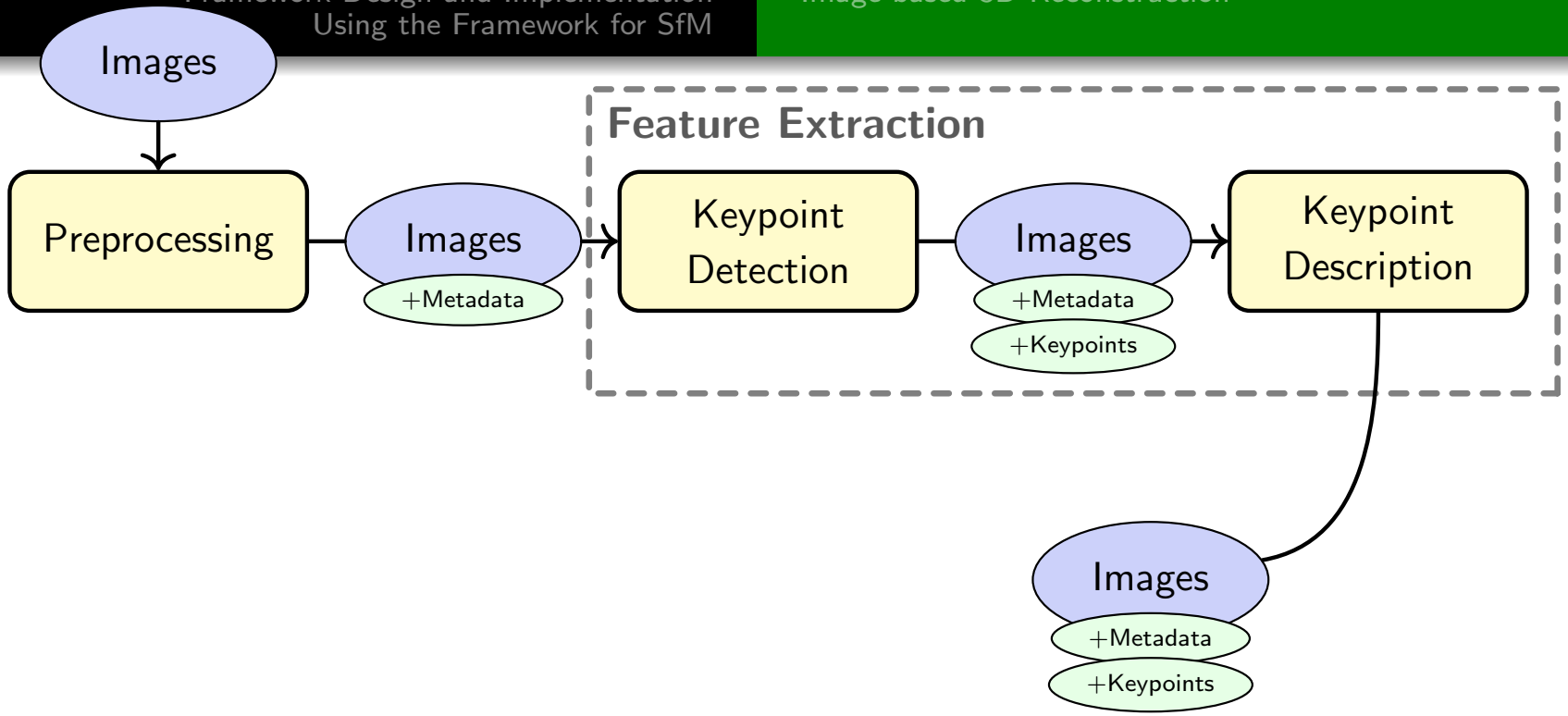
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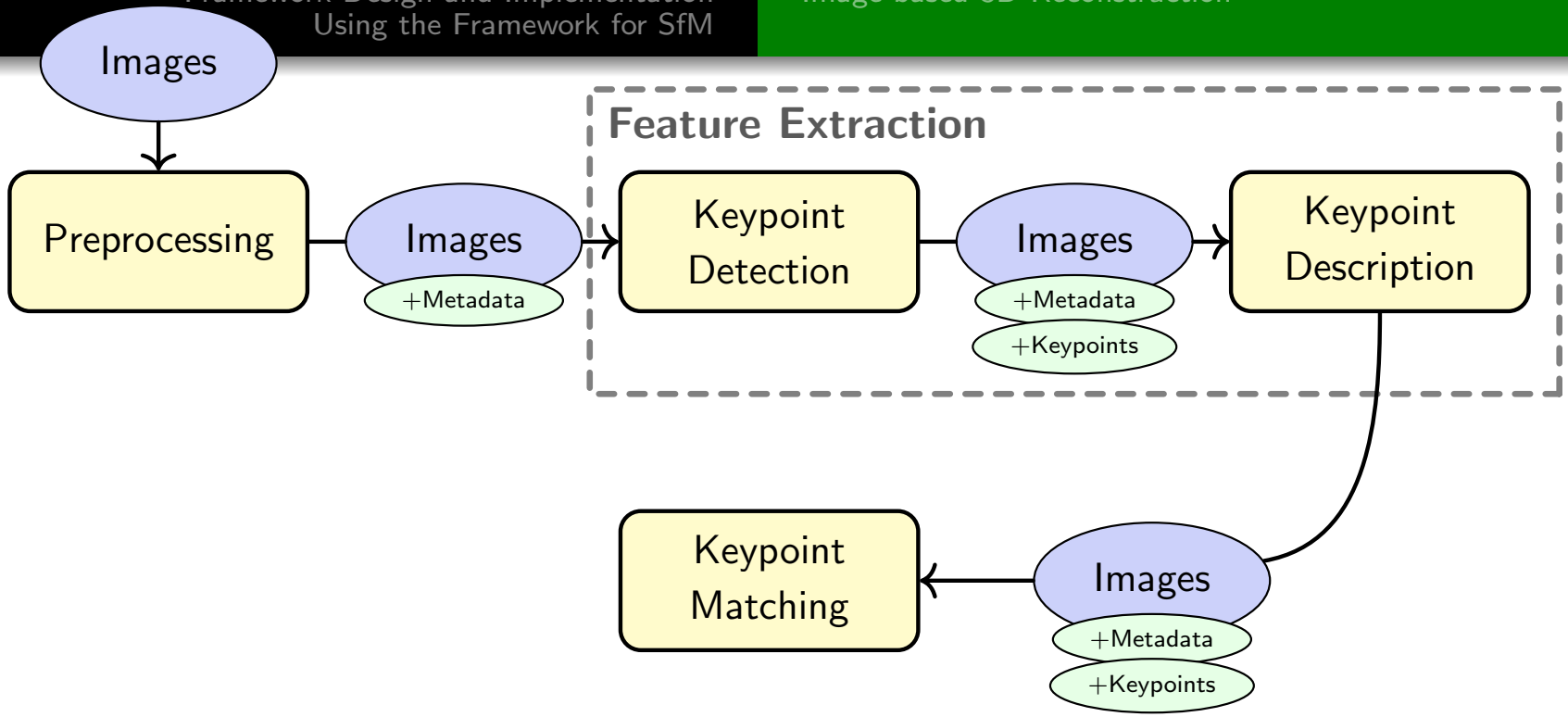
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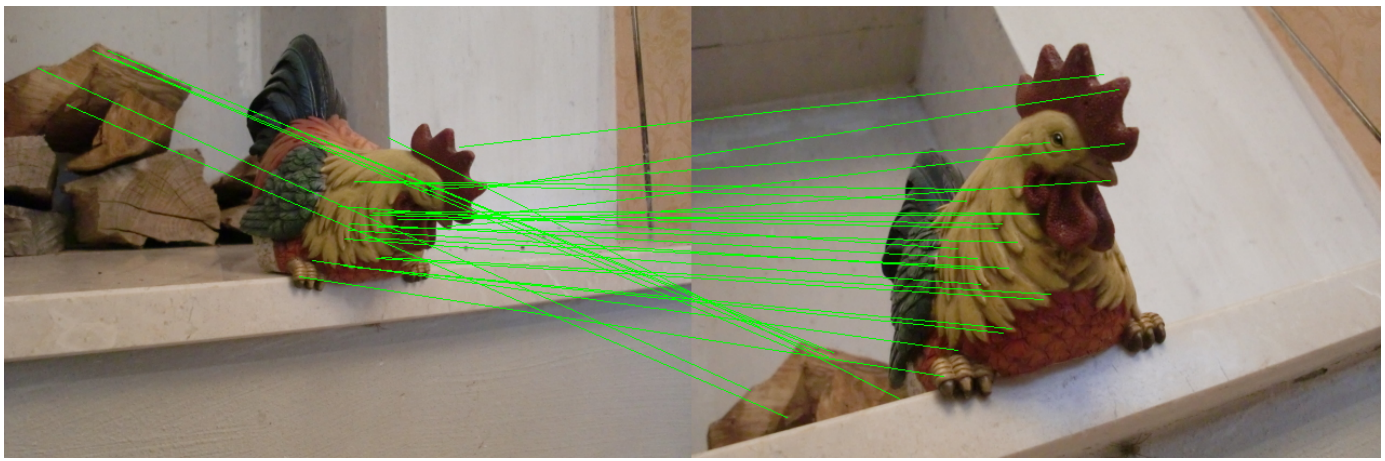

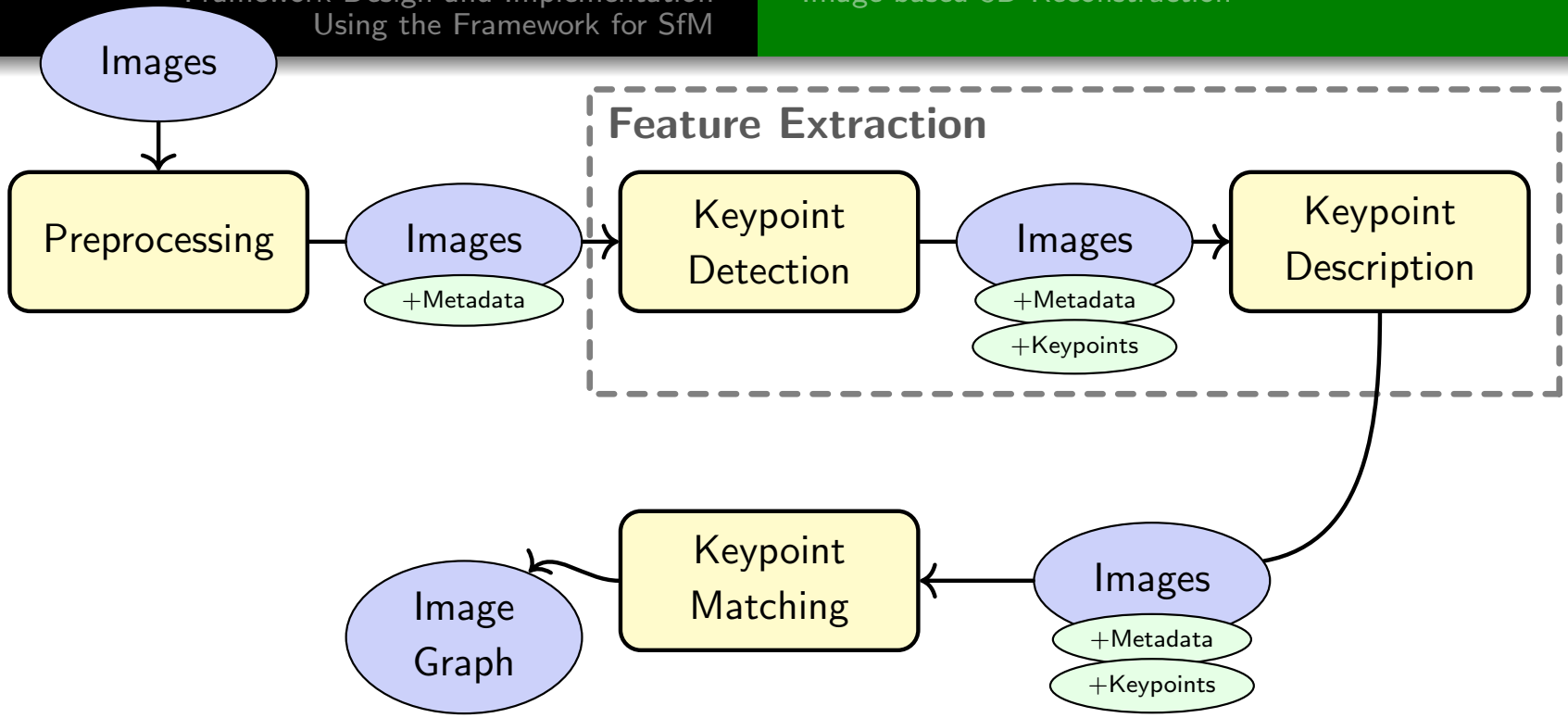
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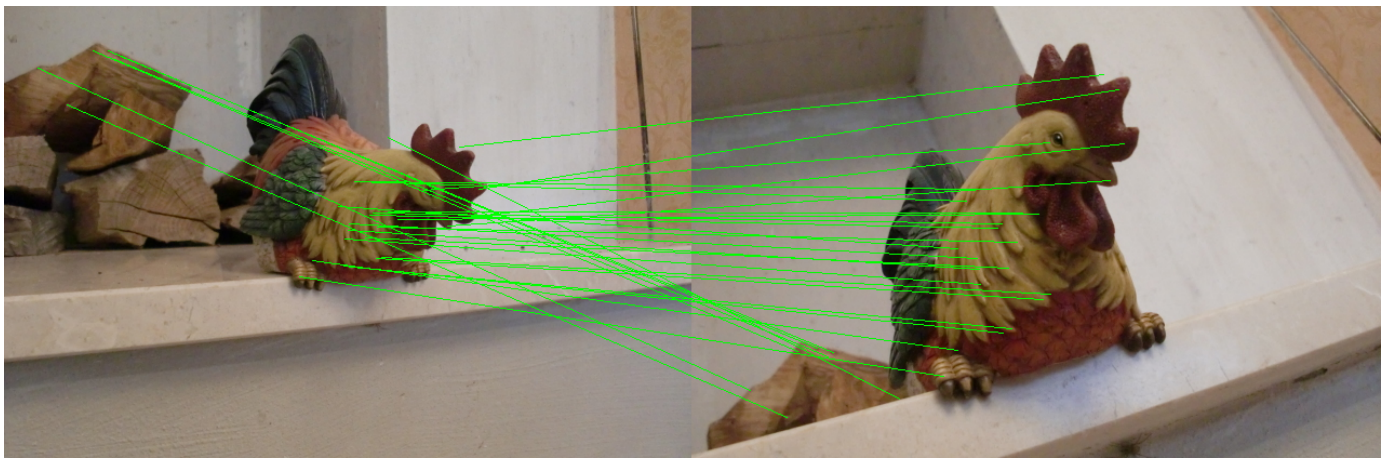

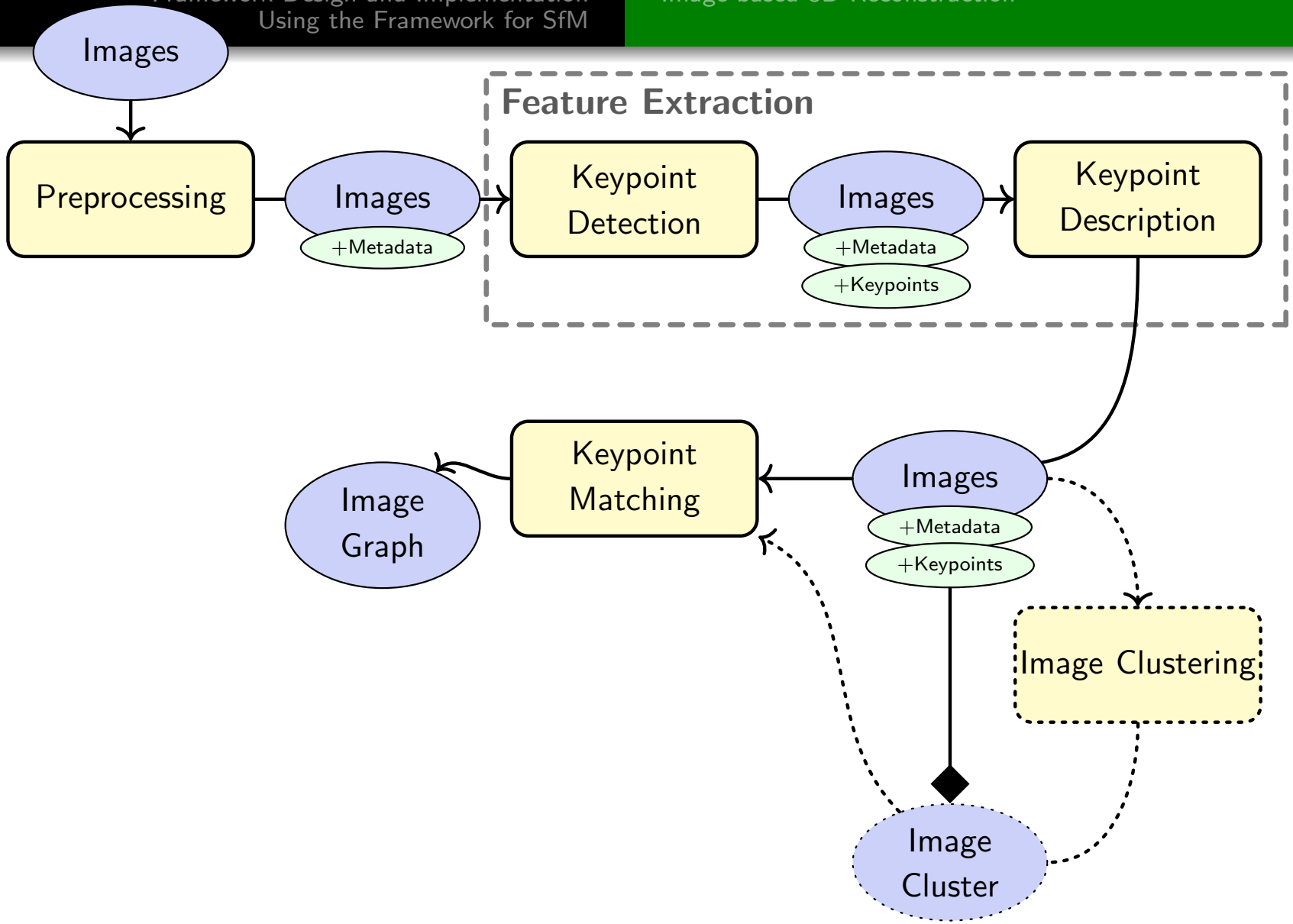
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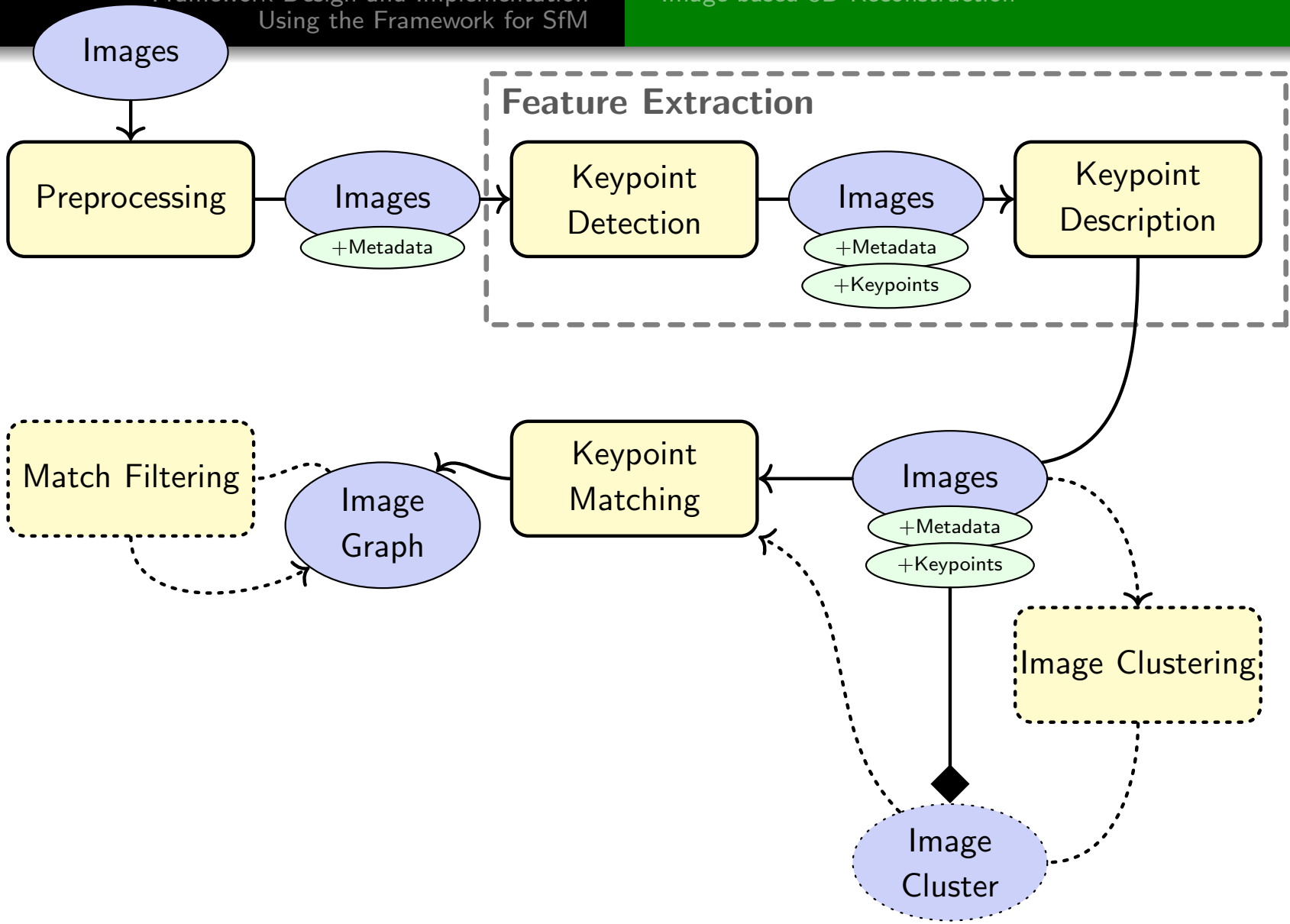
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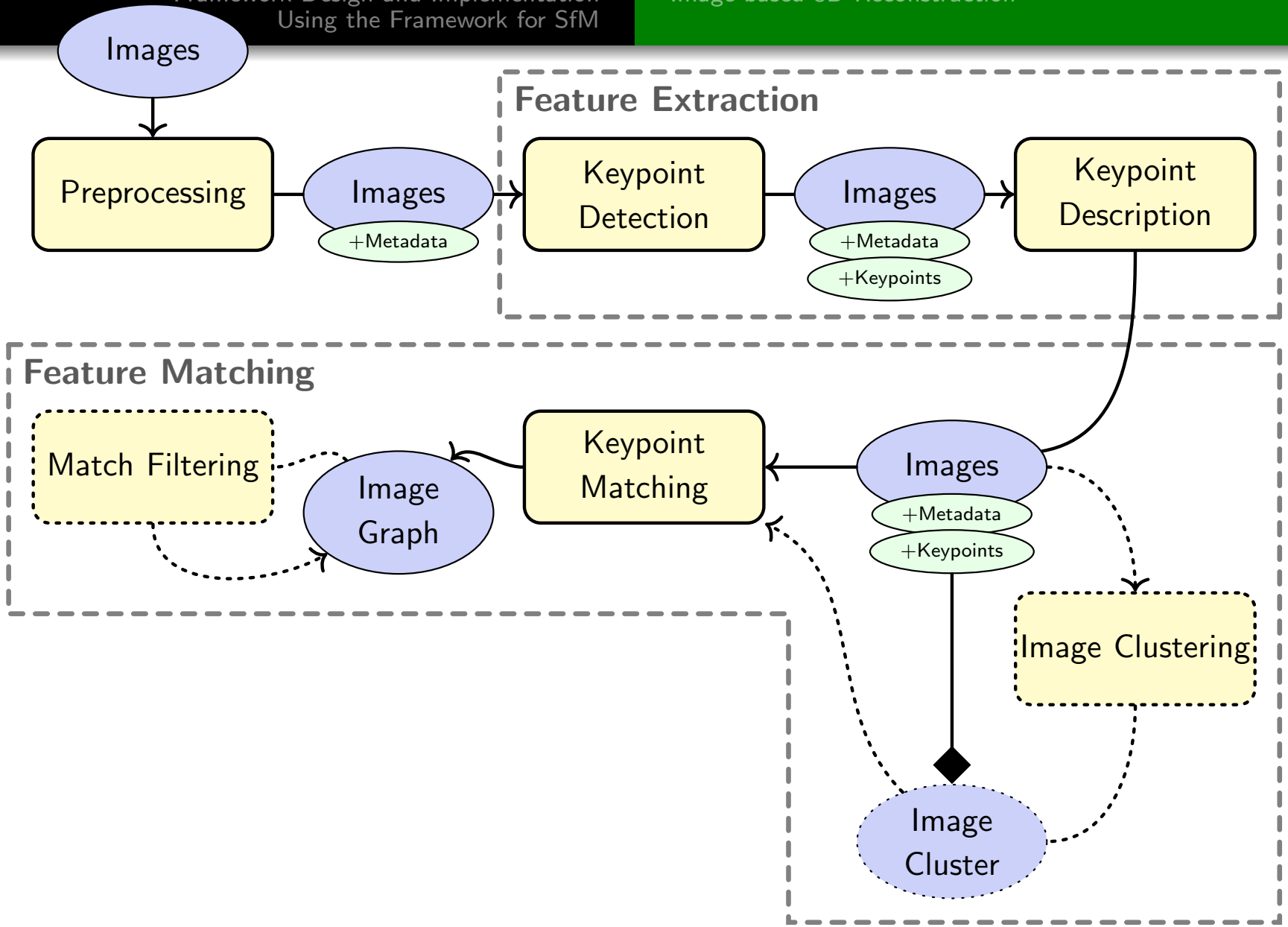
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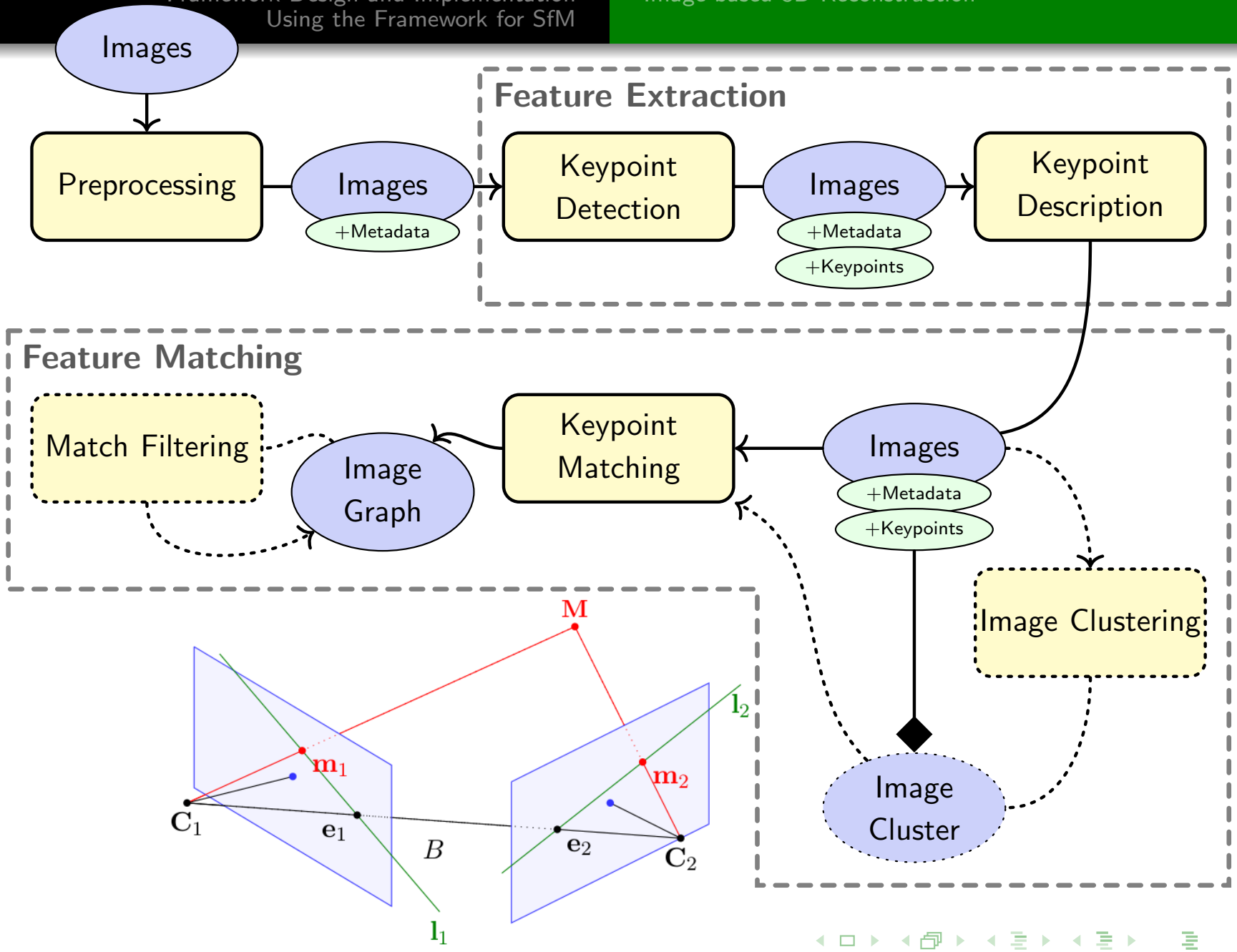
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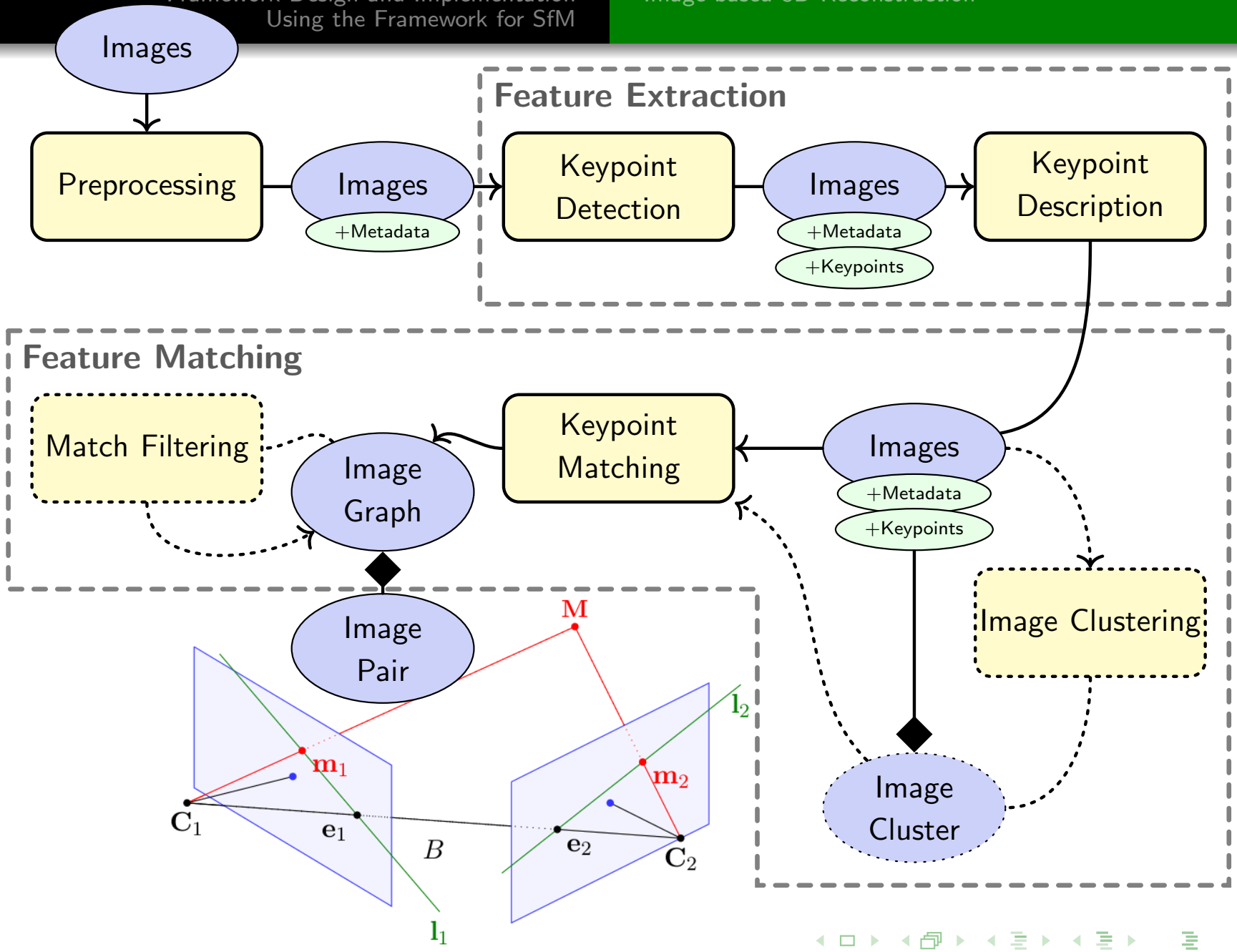
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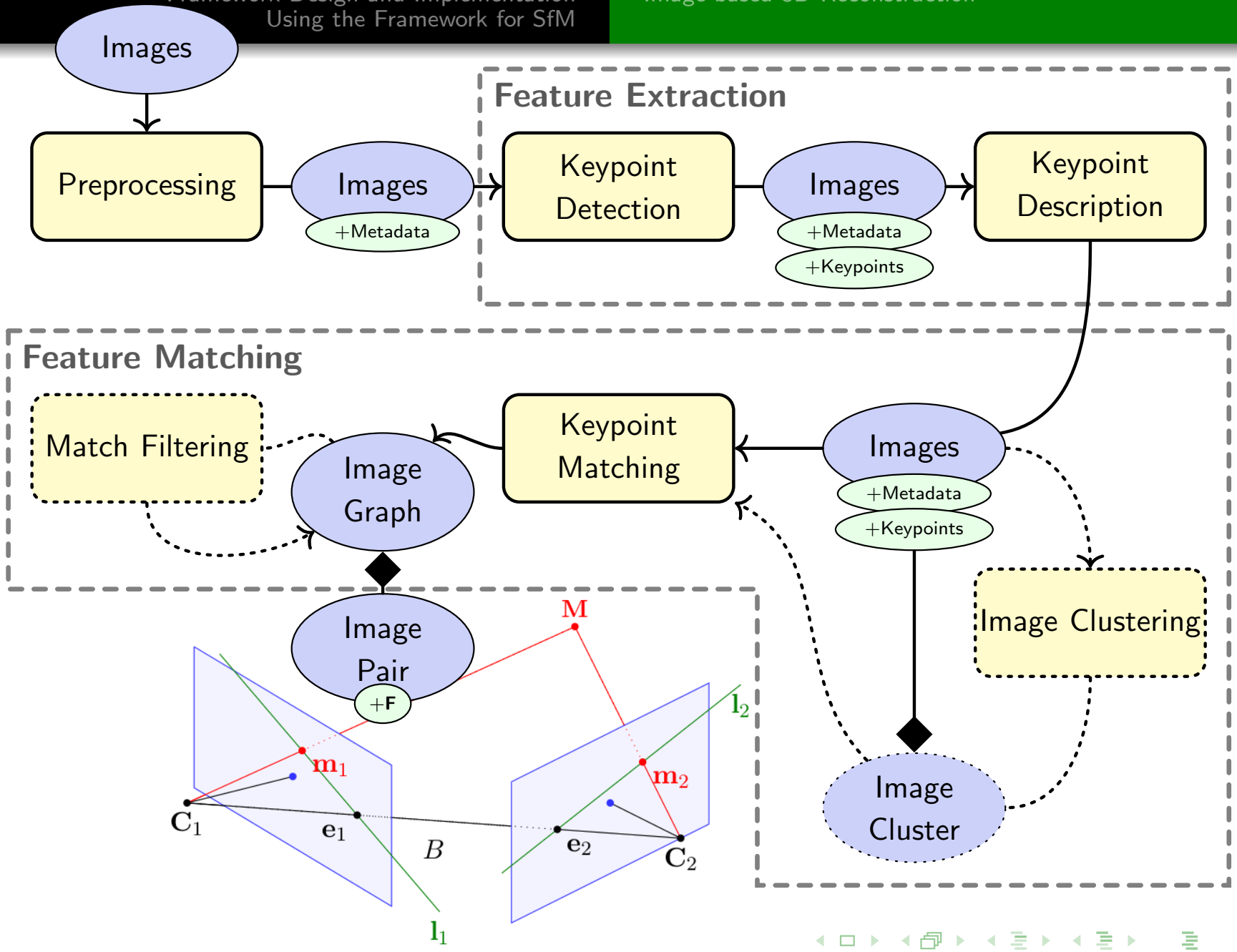
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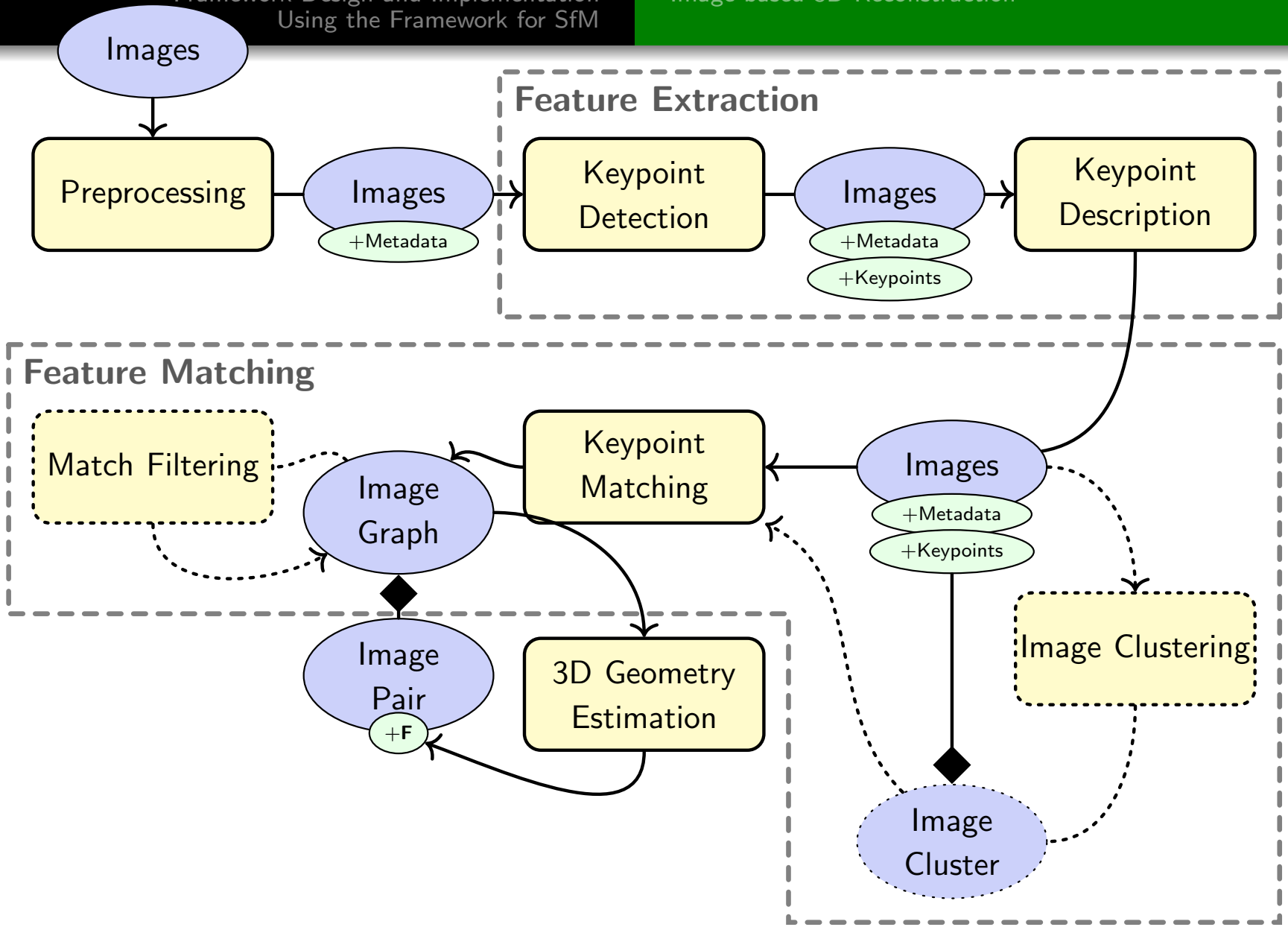
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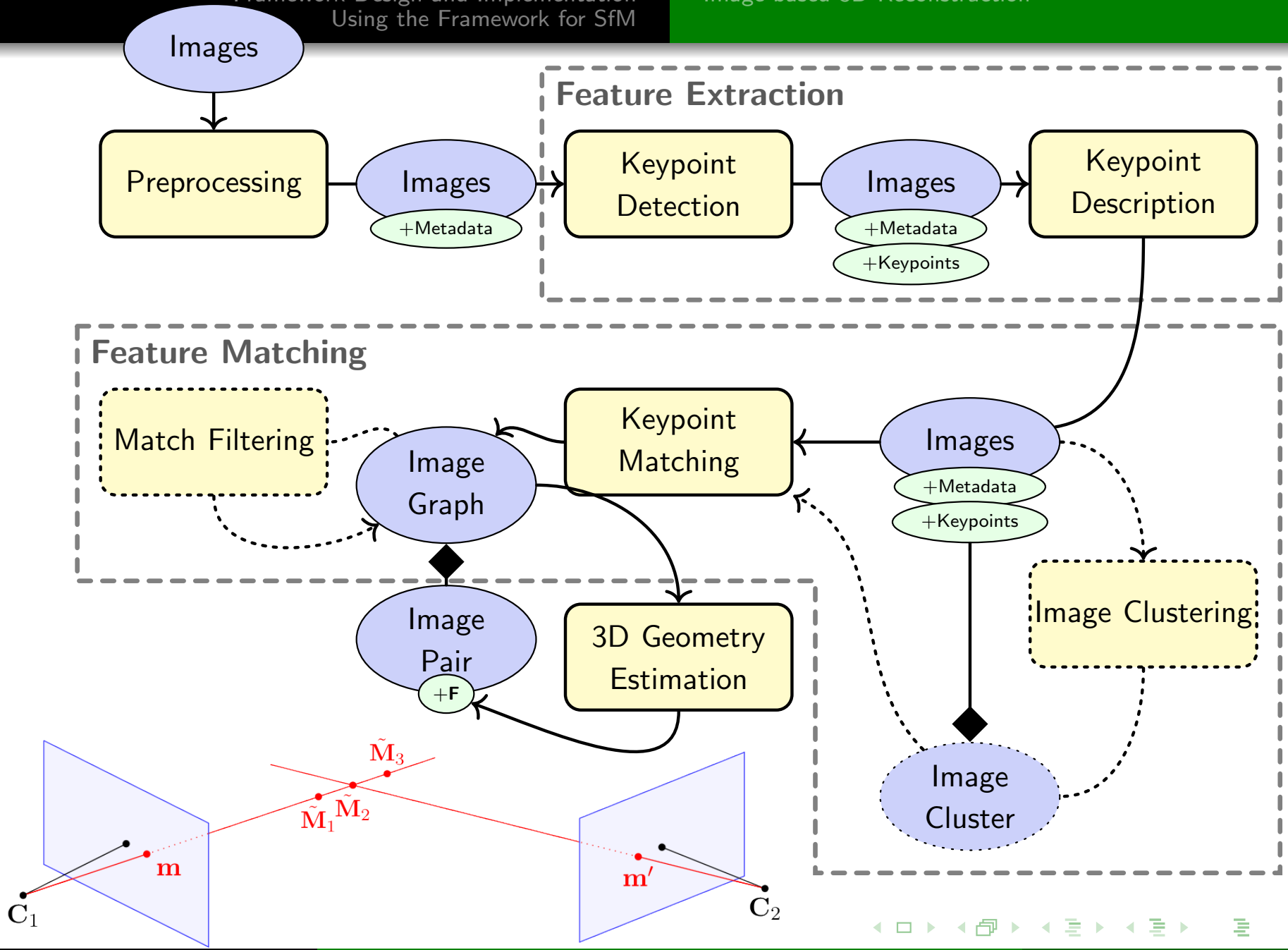
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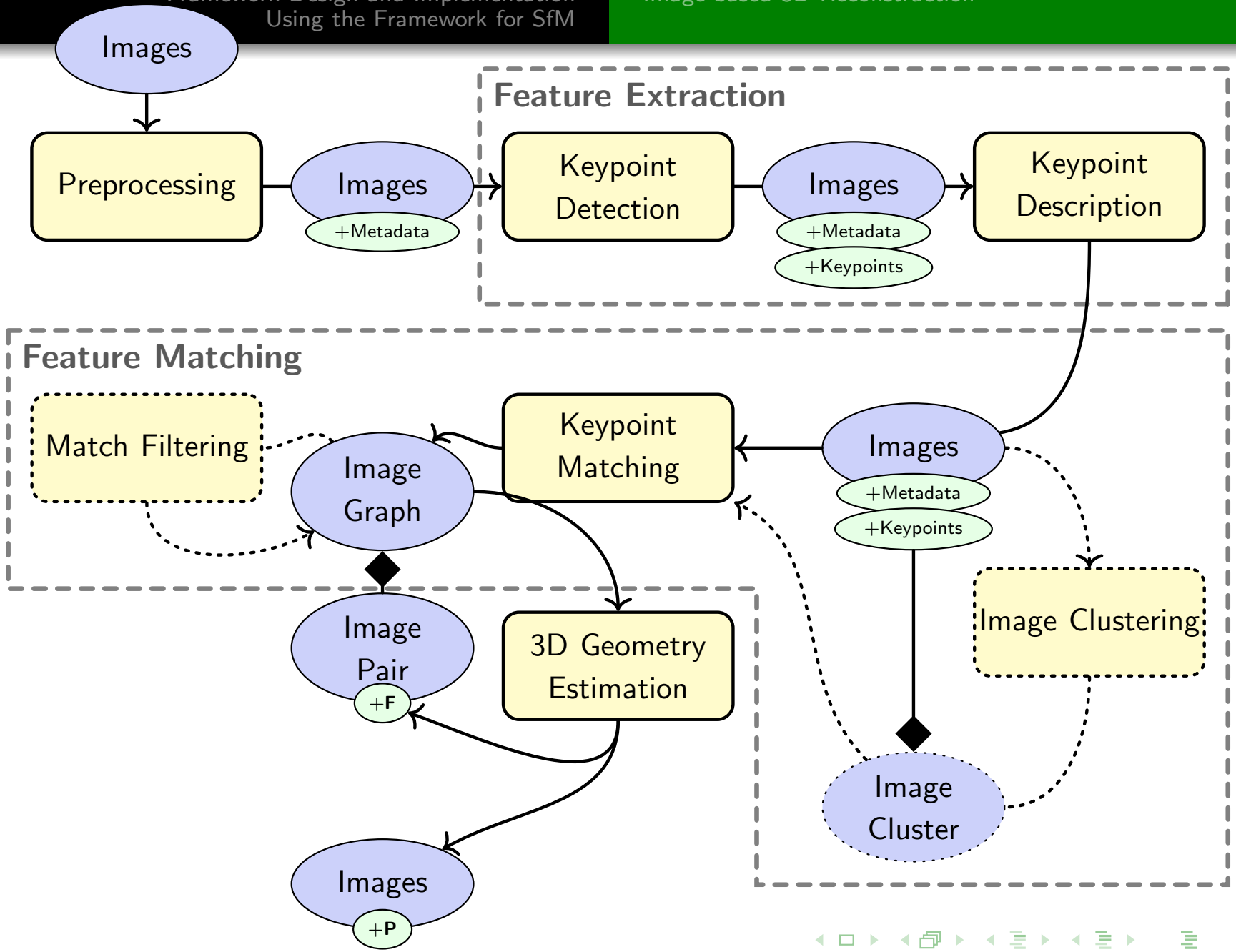
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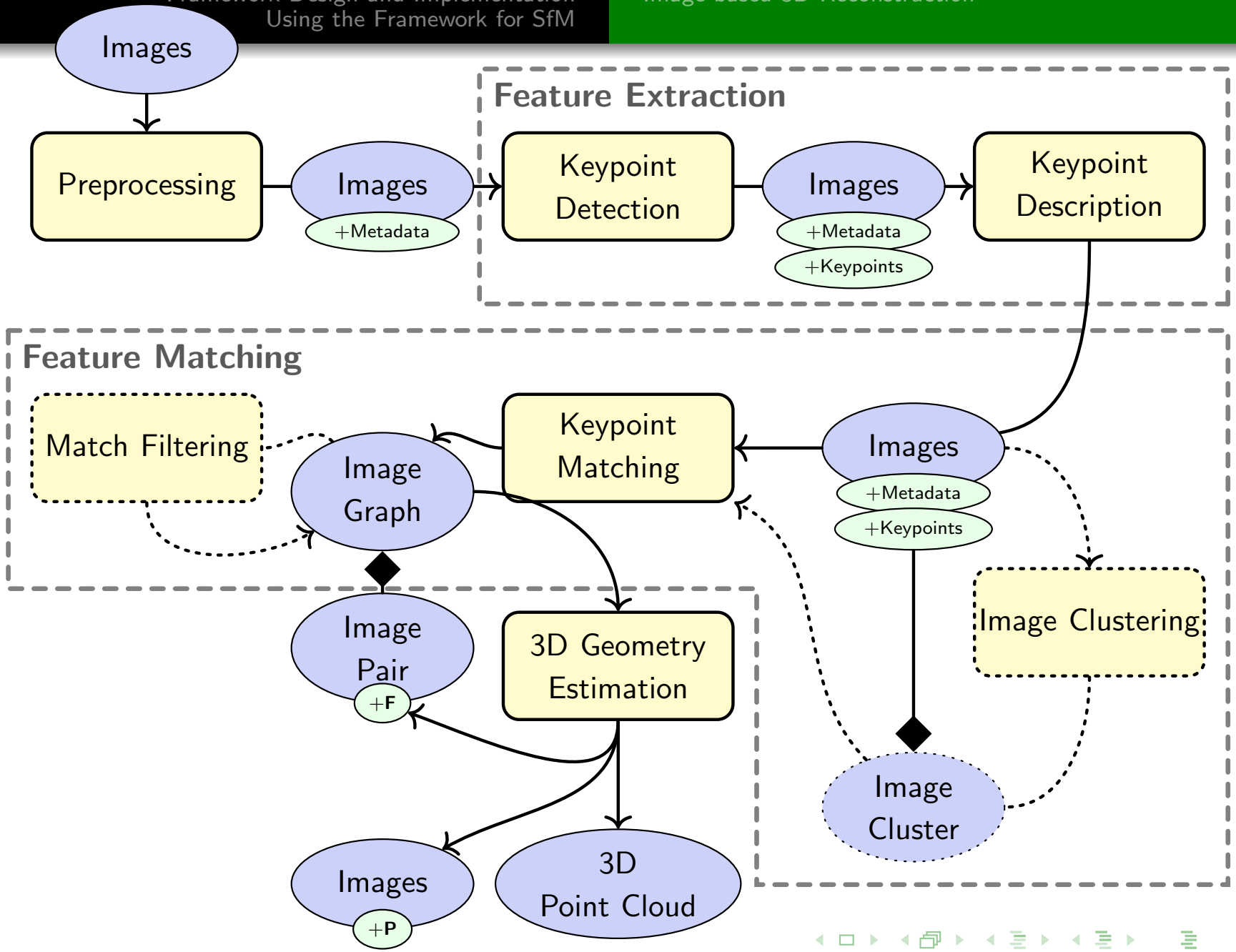
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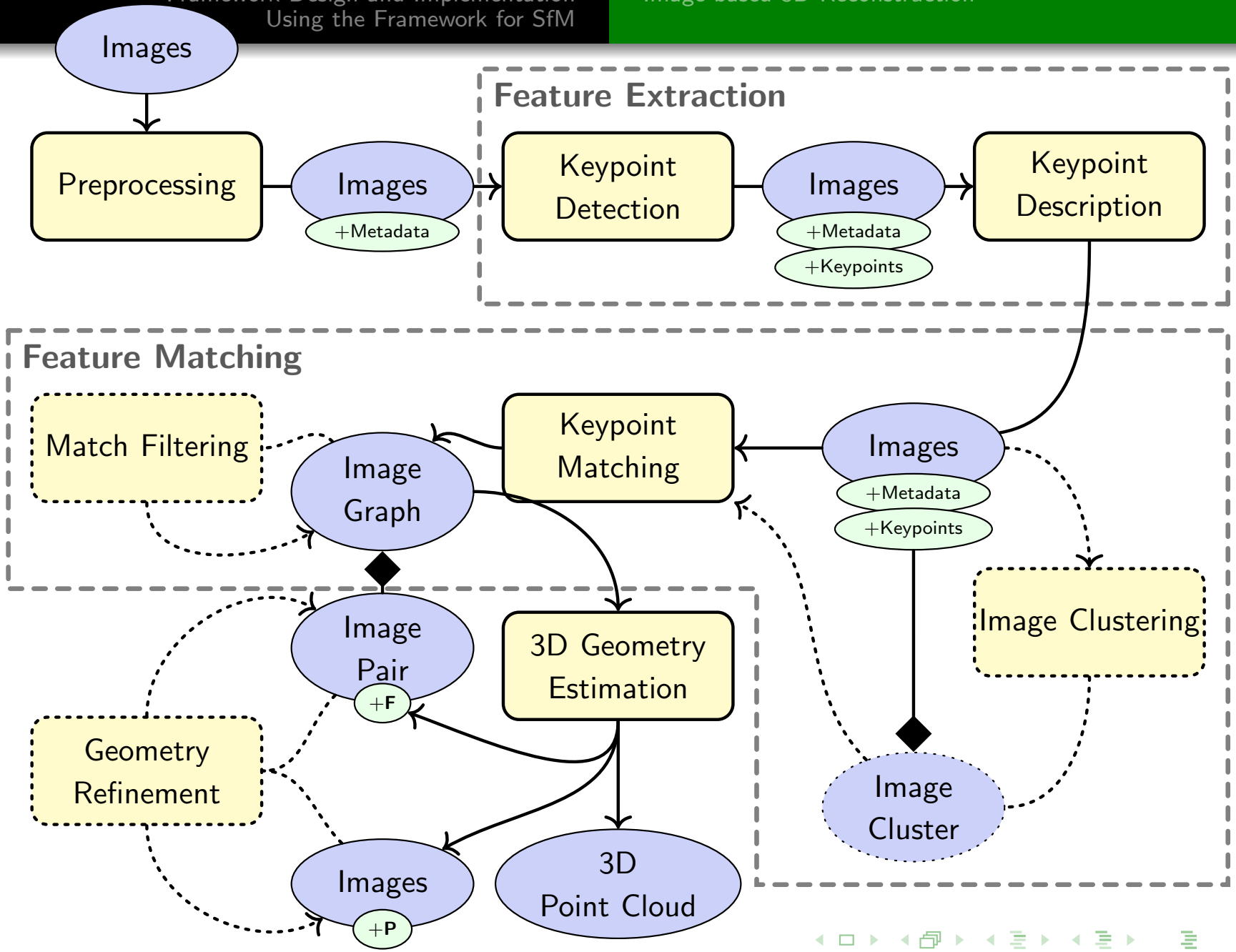
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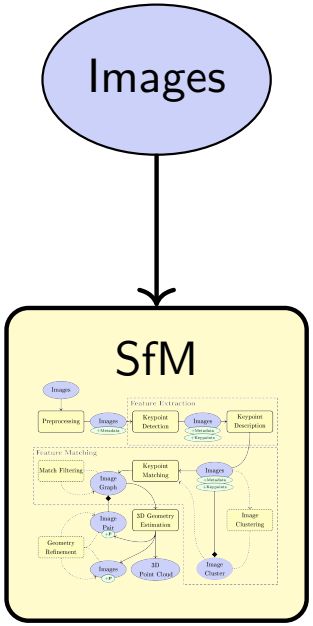
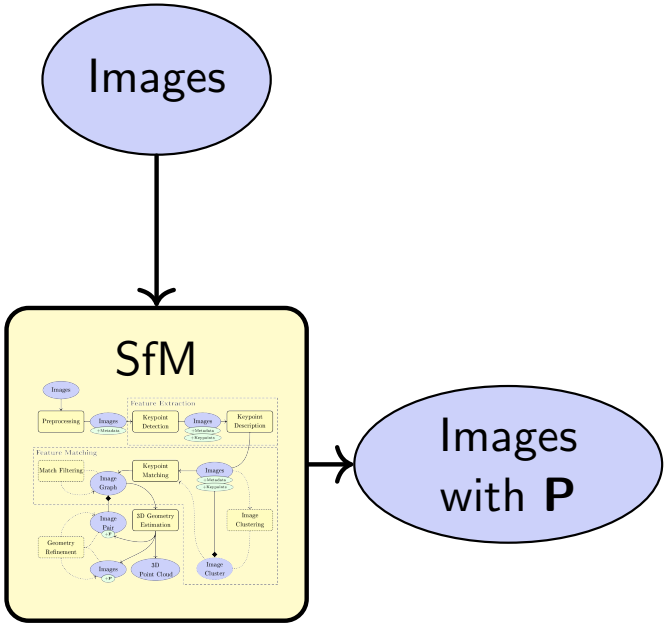
Highlevel overview of image-based 3D reconstruction



Mesh

Highlevel overview of image-based 3D reconstruction



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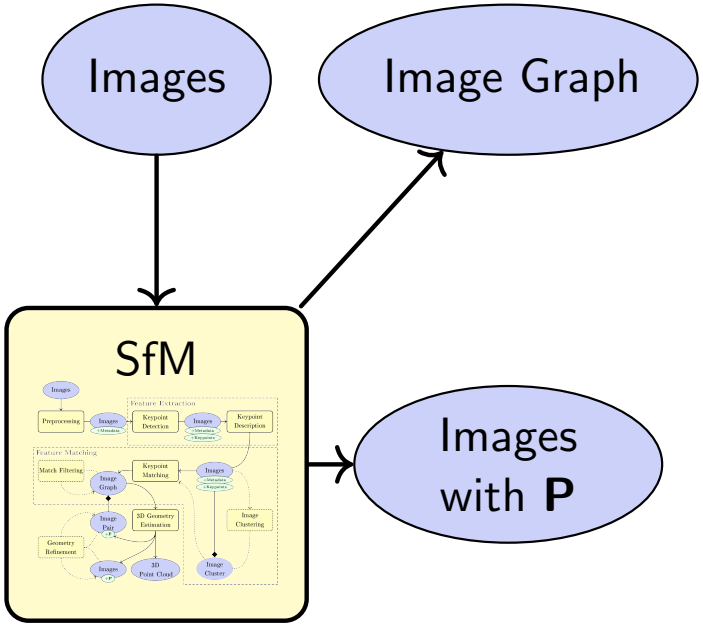

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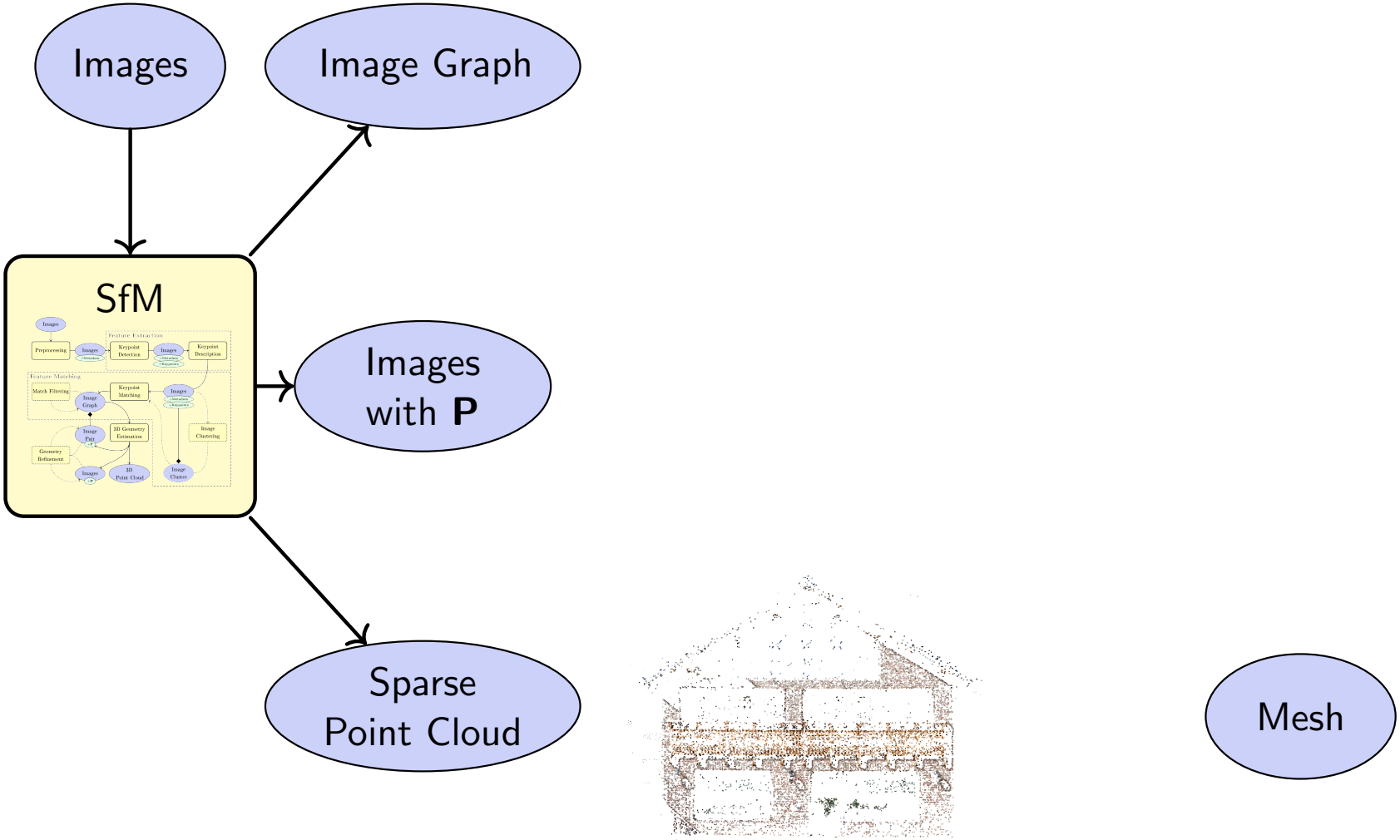

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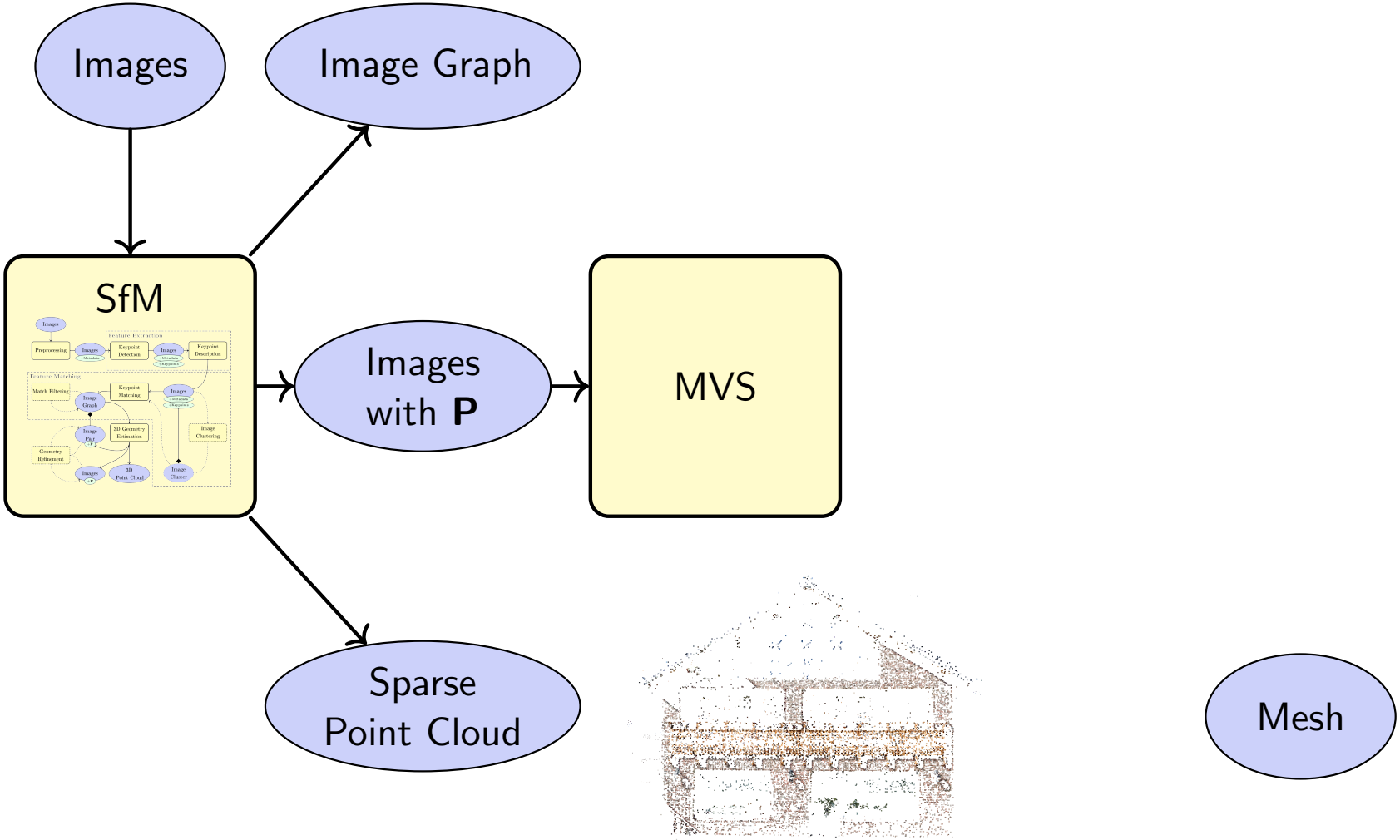

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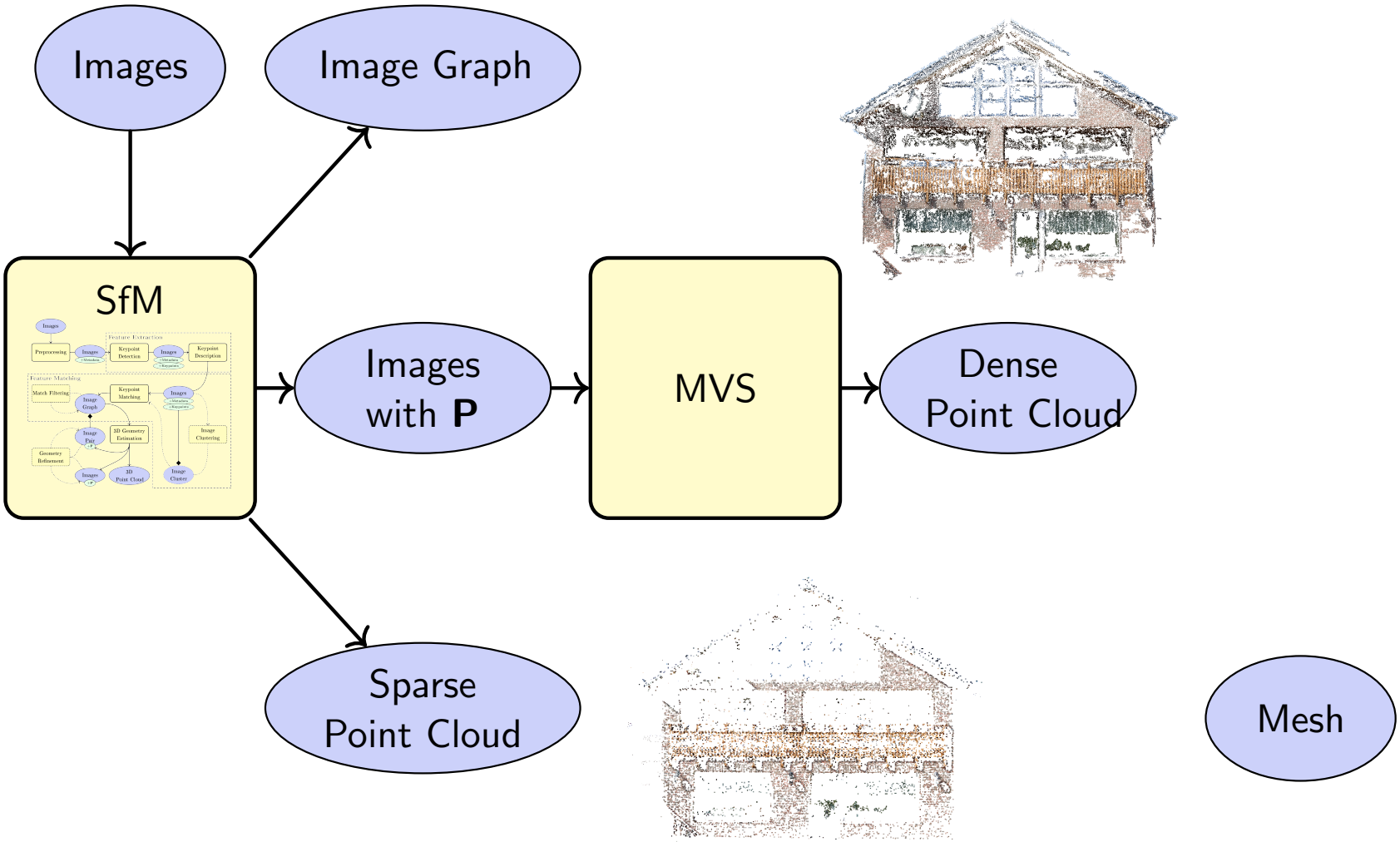

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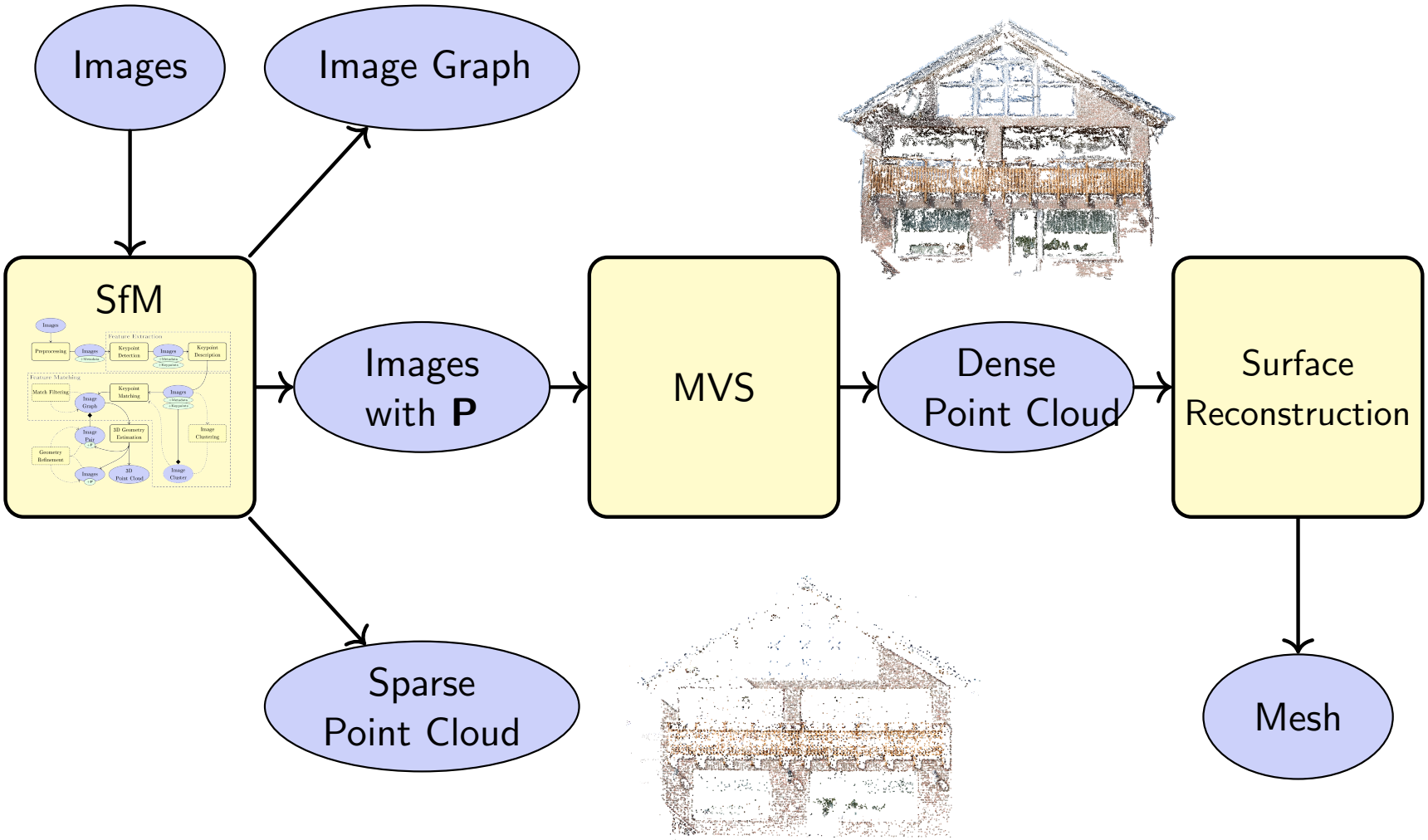

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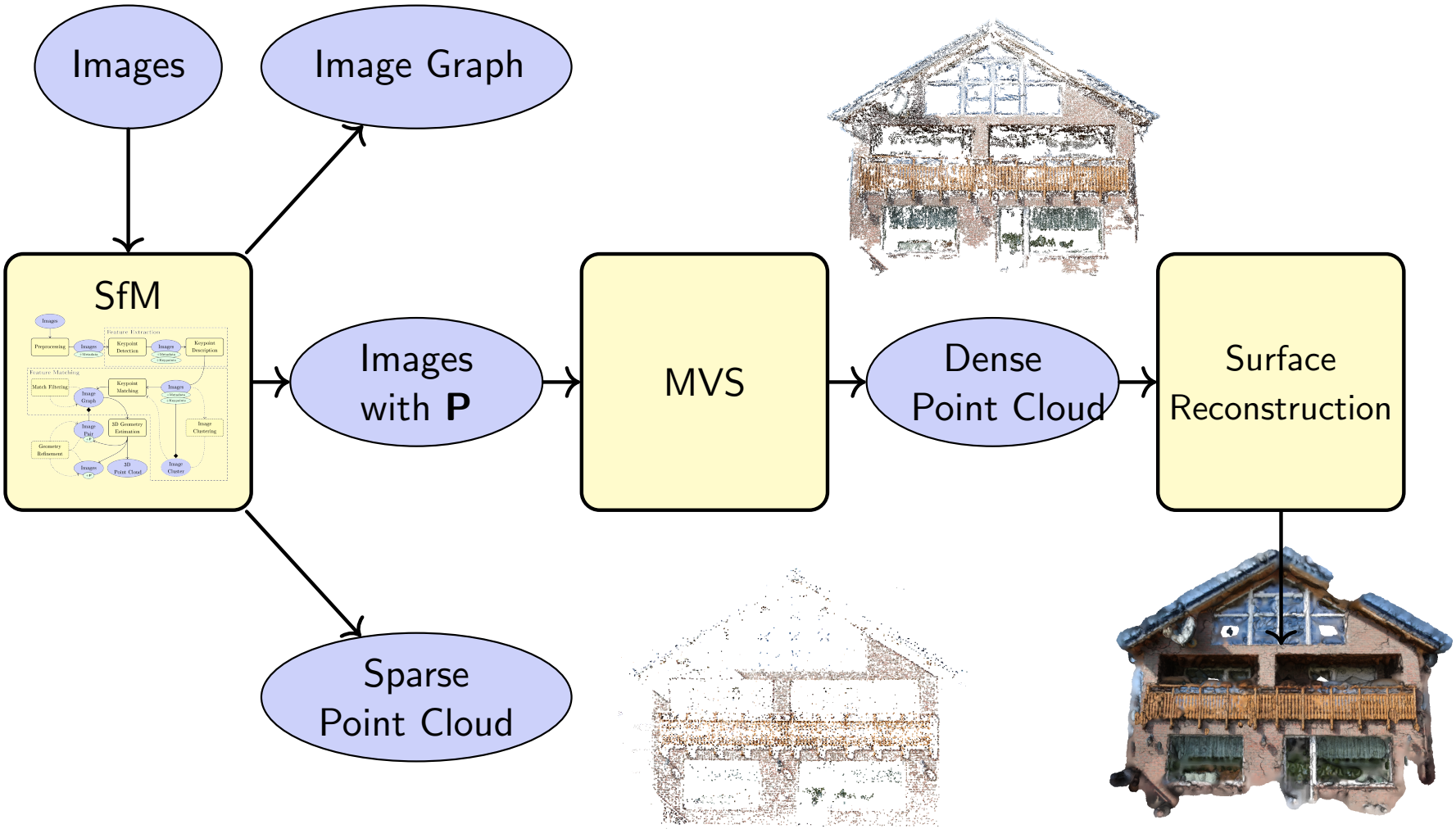

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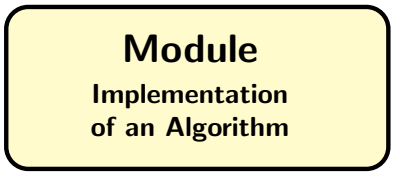

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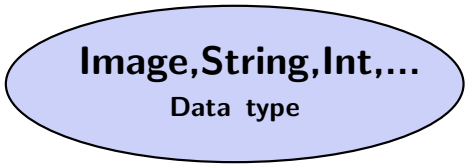
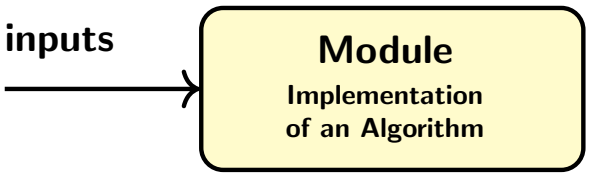


Module and Data

Module



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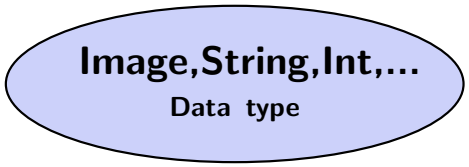

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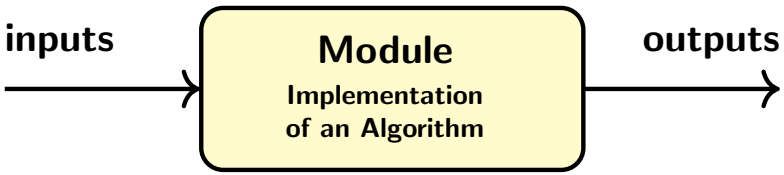
Module



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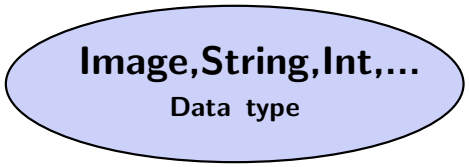

Module and Data

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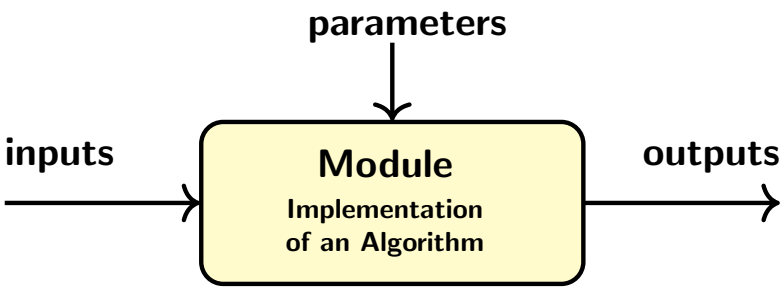

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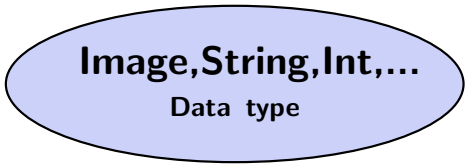

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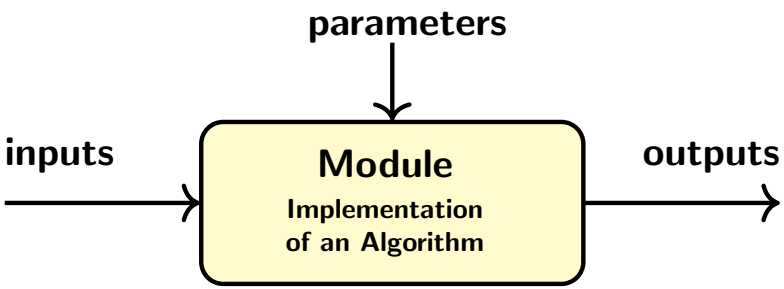

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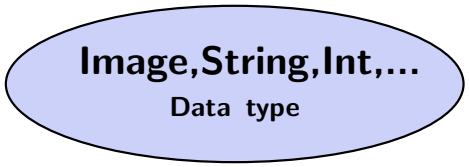
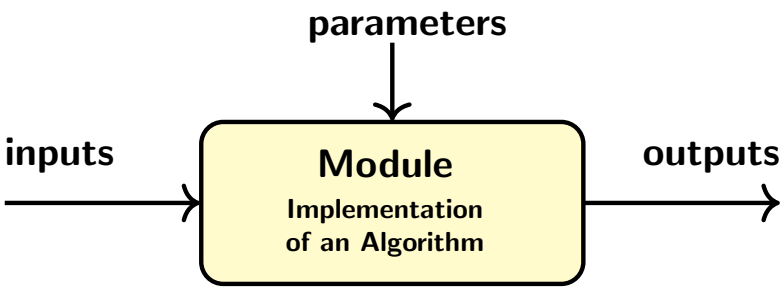


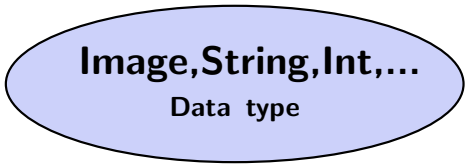
- clear interface $\rightarrow$ reuse of code in different contexts

Module and Data

Module



Data



- clear interface $\rightarrow$ reuse of code in different contexts
- self-contained unit $\rightarrow$ parallelizable

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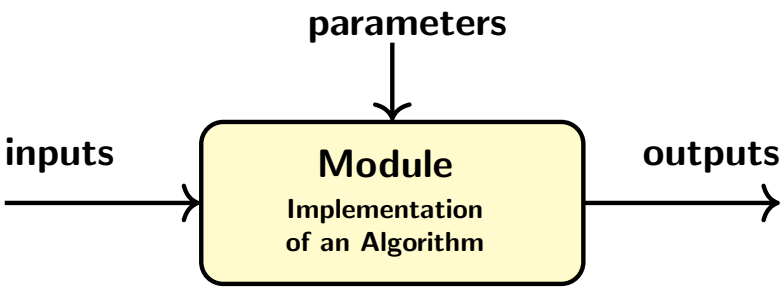

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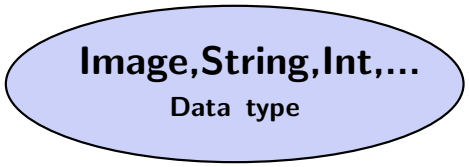

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- common data type implementations $\rightarrow$ data flow control

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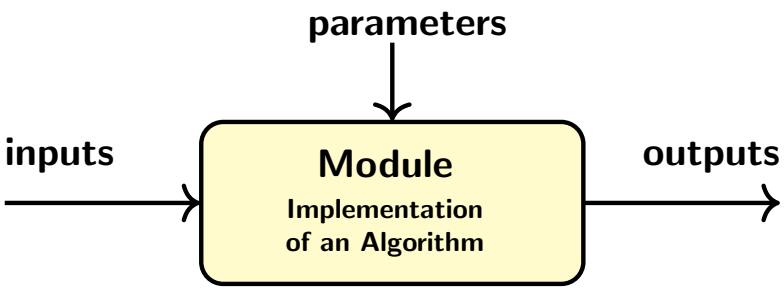

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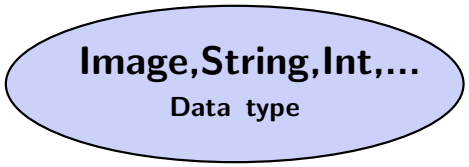
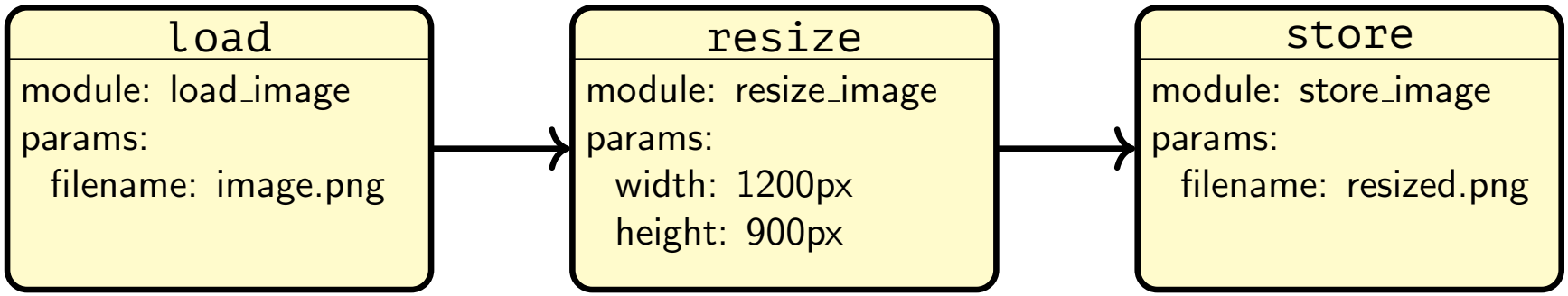


- clear interface $\rightarrow$ reuse of code in different contexts
- self-contained unit $\rightarrow$ parallelizable
- common data type implementations $\rightarrow$ data flow control
- processing chain is a dependency graph

Processing Chain



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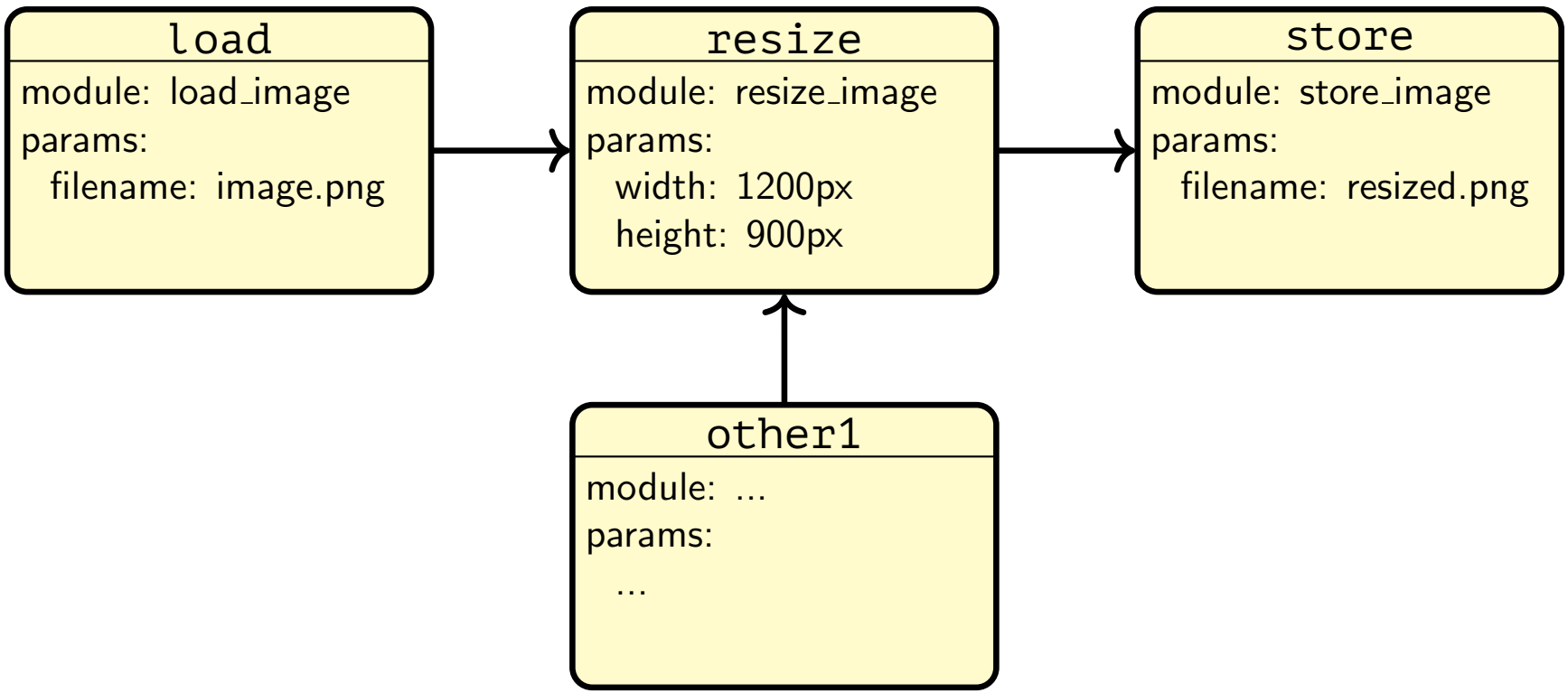

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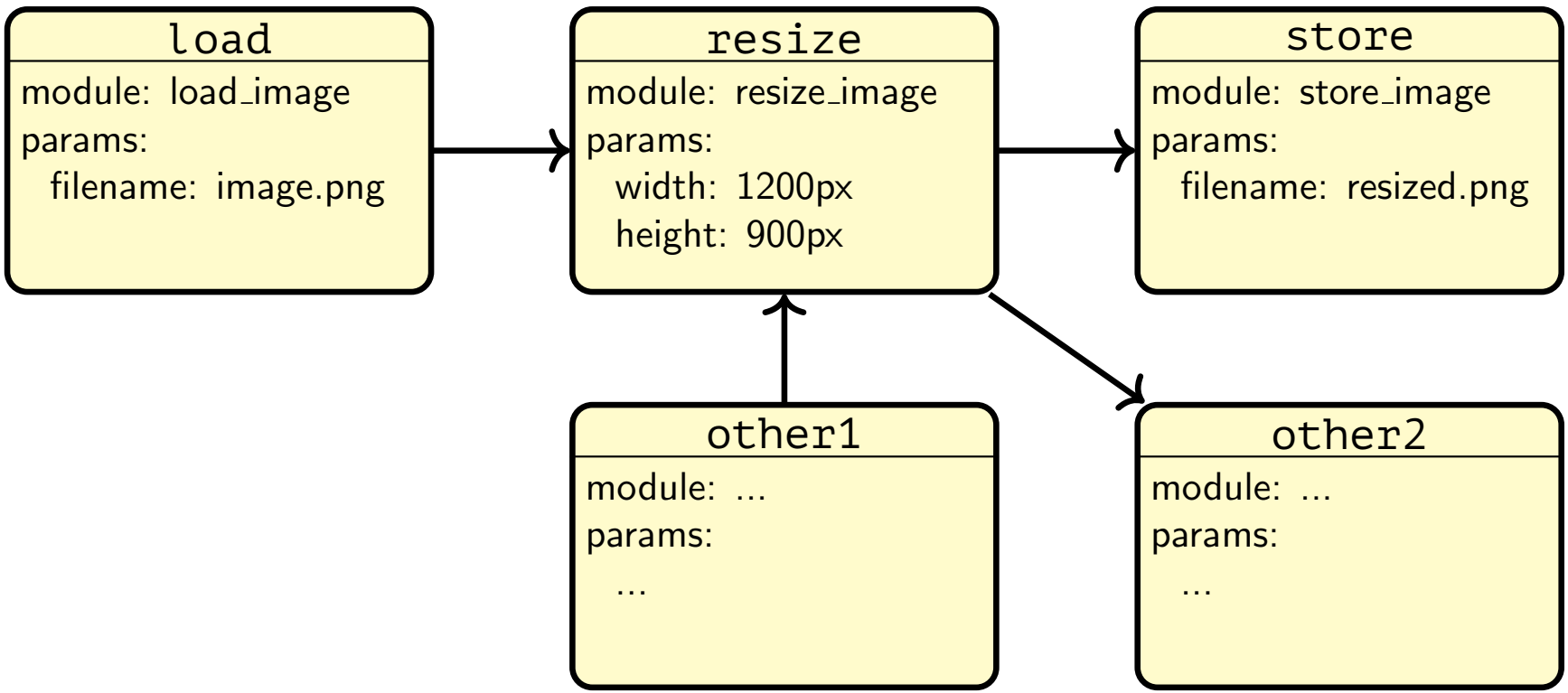

Implementation of a Module

```
1 #include <uipf/data.hpp>
2 #include <uipf/data/opencv.hpp>
3
4 using namespace uipf;
5
6 #define UIPF_MODULE_ID "opencv.imgproc.resize"
7 #define UIPF_MODULE_NAME "Resize Image"
8 #define UIPF_MODULE_CATEGORY "opencv"
9 #define UIPF_MODULE_CLASS OpenCVResizeImage
  // ...
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Implementation of a Module

```
11 #define UIPF_MODULE_INPUTS \
12   {"image", DataDescription(data::OpenCVMat::id(), \
13             "the input image.")}
14
15 #define UIPF_MODULE_OUTPUTS \
16   {"image", DataDescription(data::OpenCVMat::id(), \
17             "the resized image.")}
18
19 #define UIPF_MODULE_PARAMS \
20   {"width",  ParamDescription("new width.") }, \
21   {"height", ParamDescription("new height.") }
22
23 #include <uipf/Module.hpp>
24
25 void OpenCVResizeImage::run() {
26   // Module Implementation goes here.
27 }
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Implementation of a Module: Data Interface

```
1  void OpenCVResizeImage::run() {
2
3    OpenCVMat::ptr img = getInputData<OpenCVMat>("image");
4    int width = getParam<int>("width", -1);
5    int height = getParam<int>("height", -1);
6
7    // do something here
8
9    OpenCVMat::ptr newImage(new OpenCVMat(m));
10   newImage->filename = image->filename;
11   newImage->exif = image->exif;
12   setOutputData<OpenCVMat>("image", newImage);
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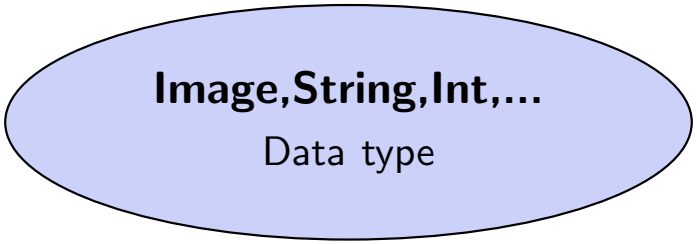
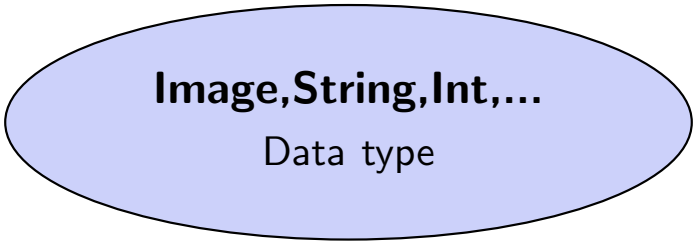
Data structure implementation



Data structure implementation



- Data structure is a container

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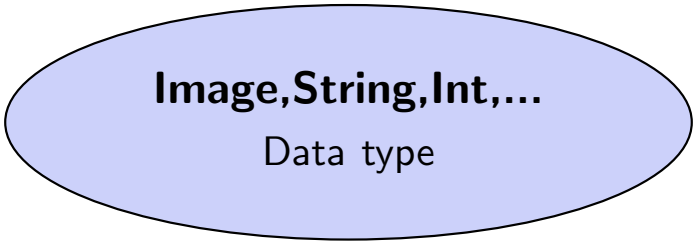
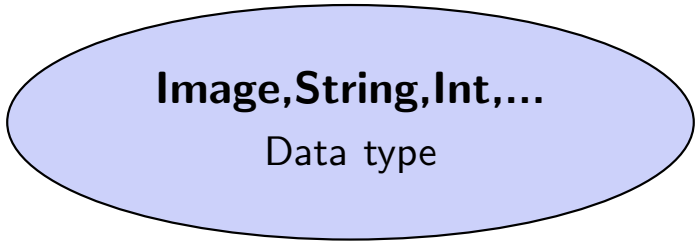


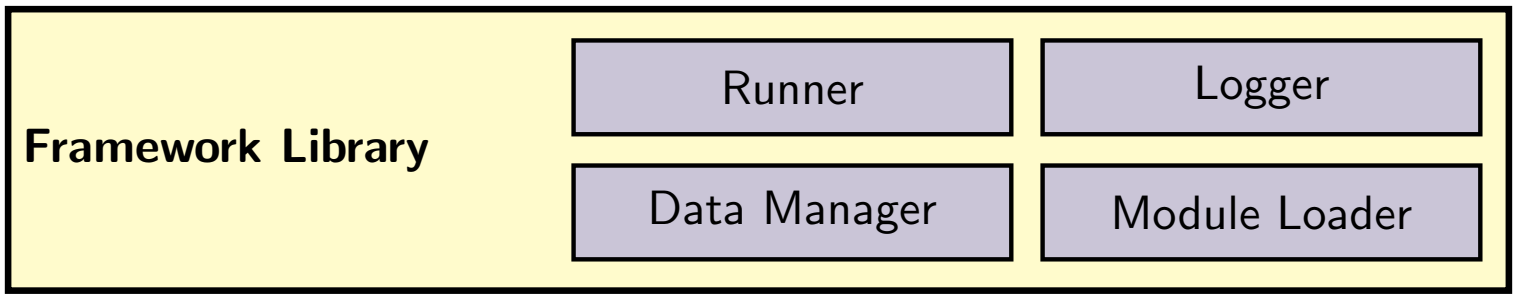
- Data structure is a container
- Interface for visualisation and serialisation

Data structure implementation

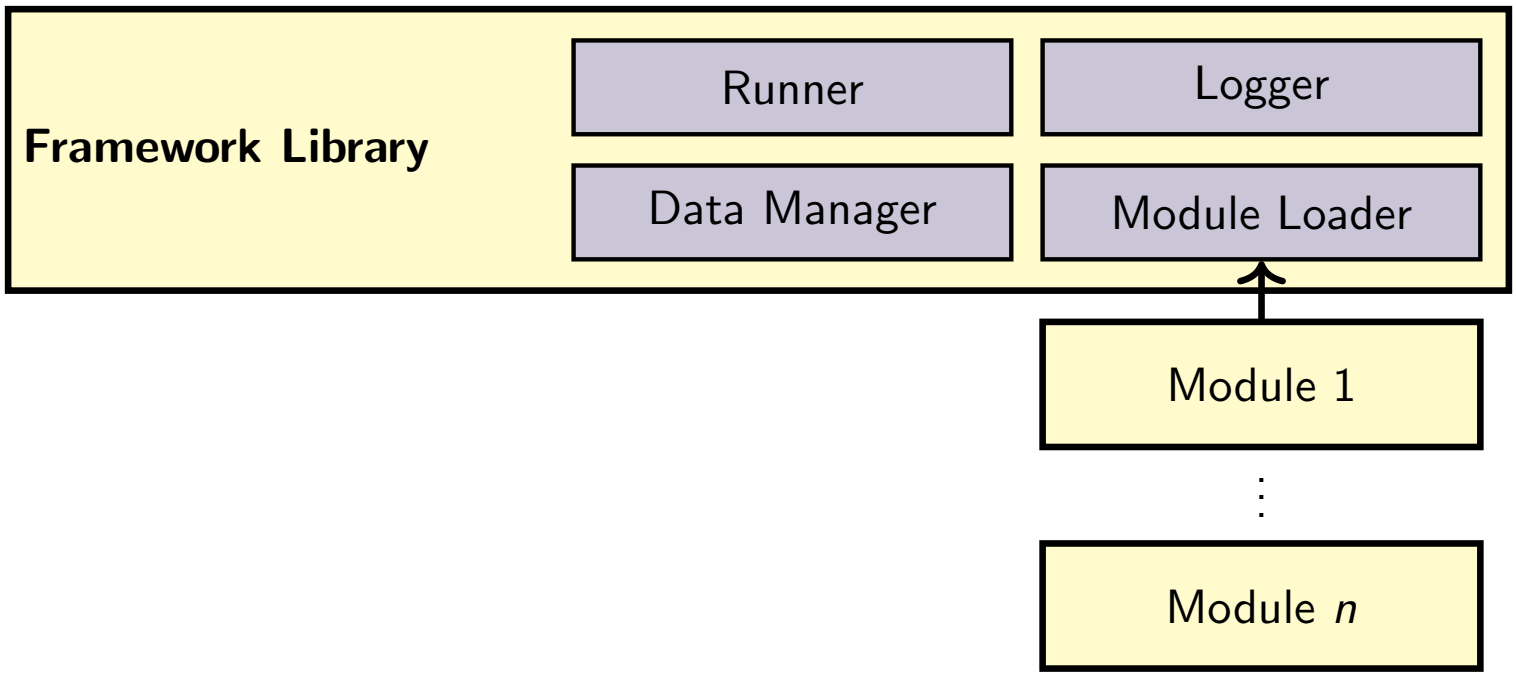


- Data structure is a container
- Interface for visualisation and serialisation
- Custom datatypes possible

Framework overview



Framework overview



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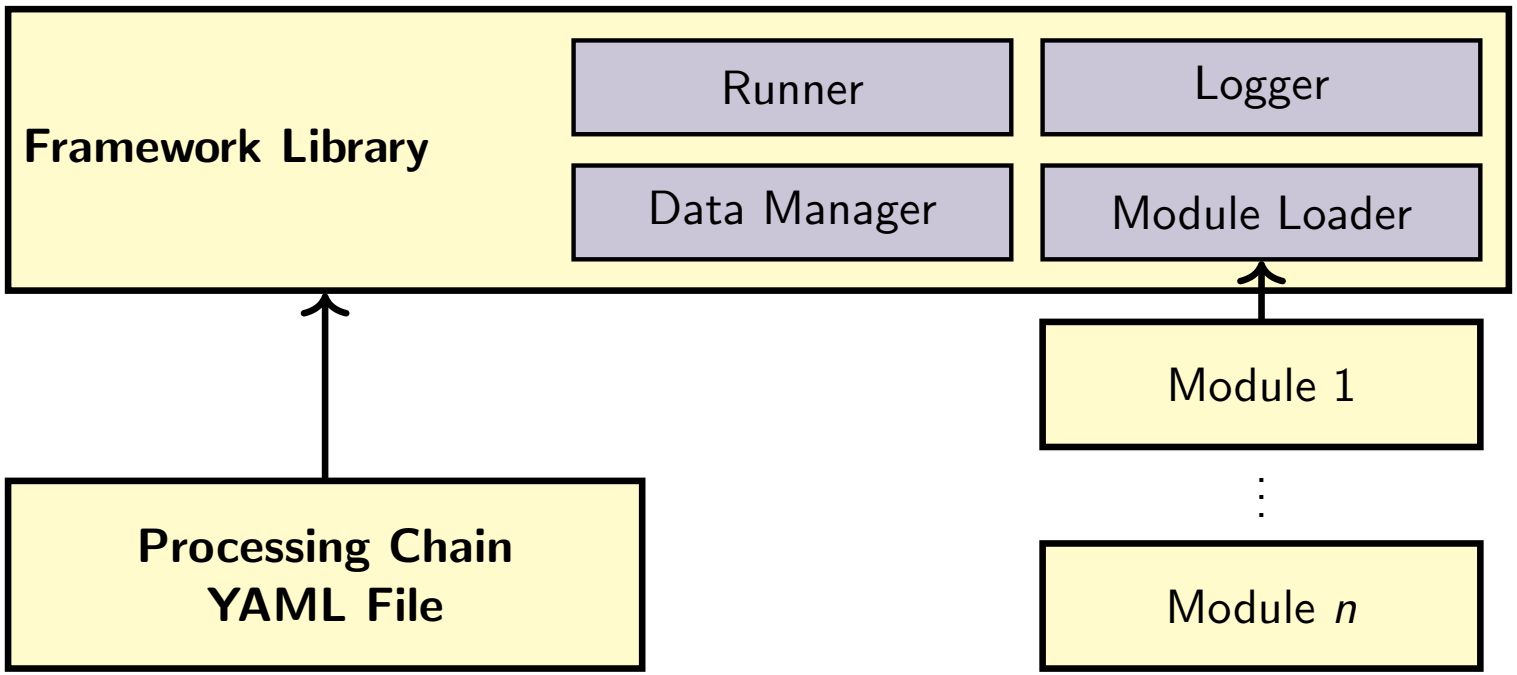

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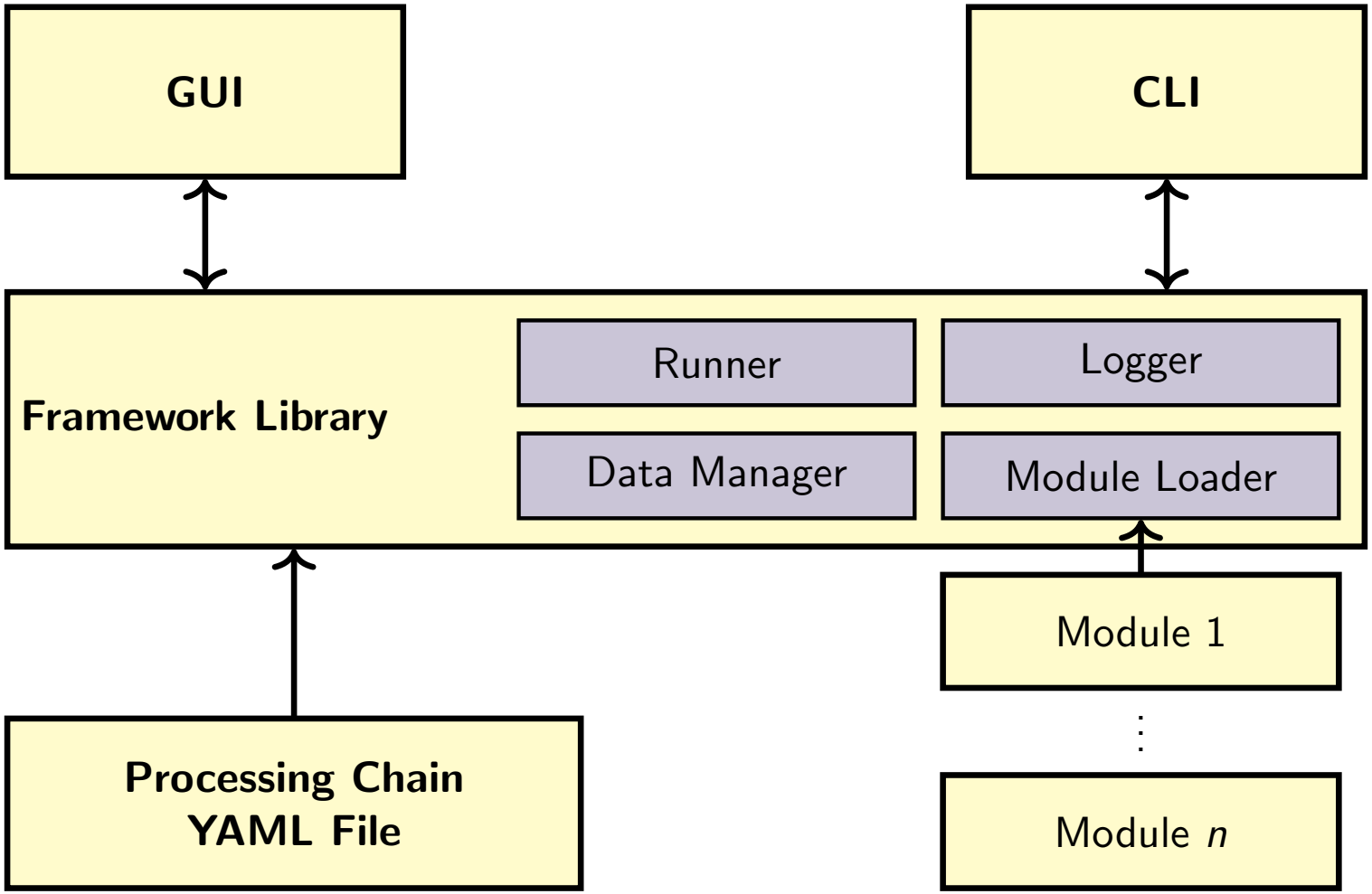
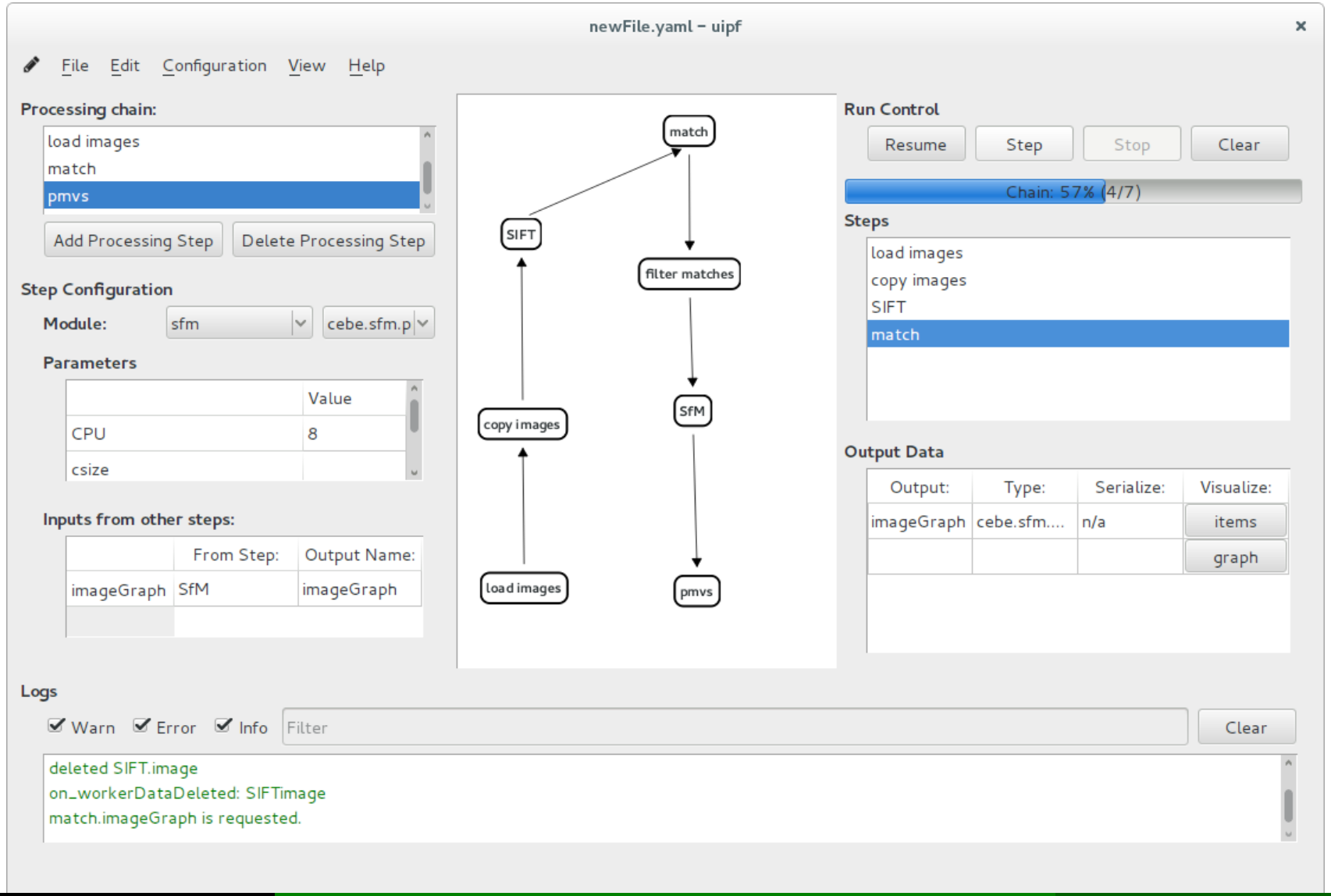


GU Interface



CL Interface

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# run a processing chain
uipf -c processing-chain.yaml
```

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# run a single module
uipf uipfsfm.keypoint -i image.jpg -o points.txt
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CL Interface

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# run a processing chain
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# run a single module
uipf uipfsfm.keypoint -i image.jpg -o points.txt

# list and document modules
uipf -l
uipf --info uipfsfm.keypoint.sift
```

Table of Contents

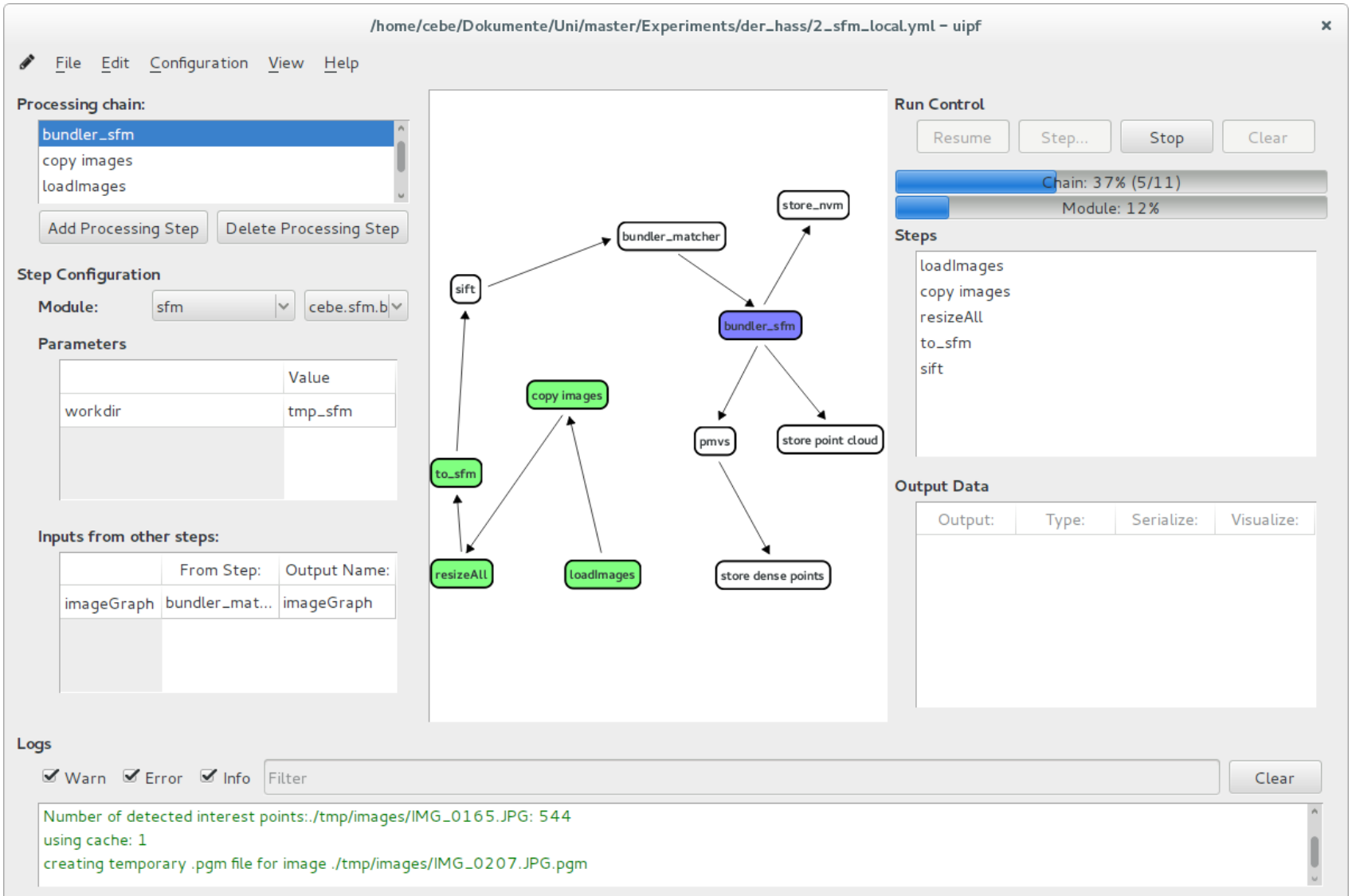
Dataset

79 images
$2592 \times 1728px$

"Der Hass" dataset by [Fuhrmann 2014]

Simon Fuhrmann, Fabian Langguth and Michael Goesele. MVE - A Multi-View Reconstruction Environment. In GCH, pages 1118, 2014.

Processing Chain



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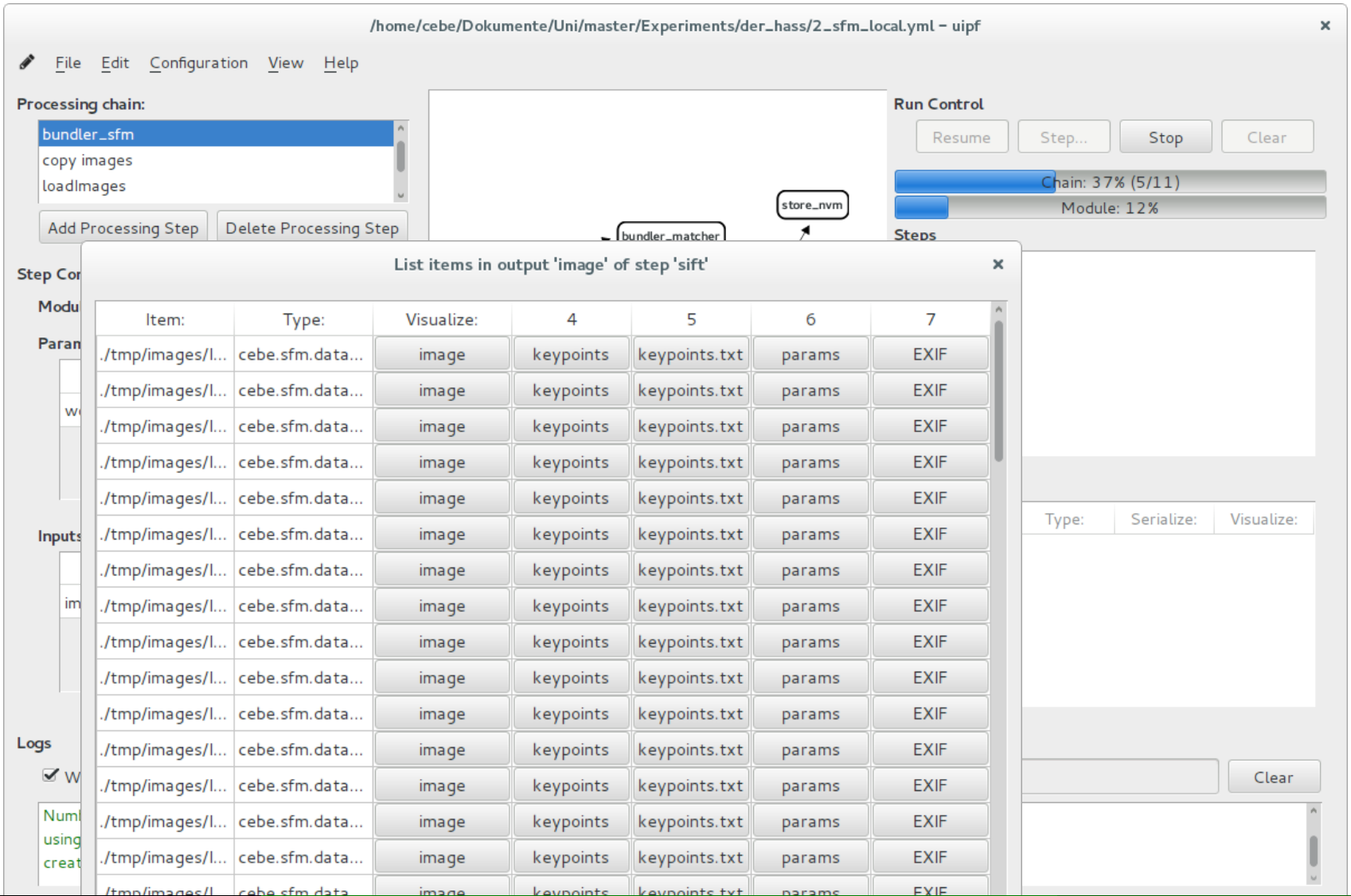

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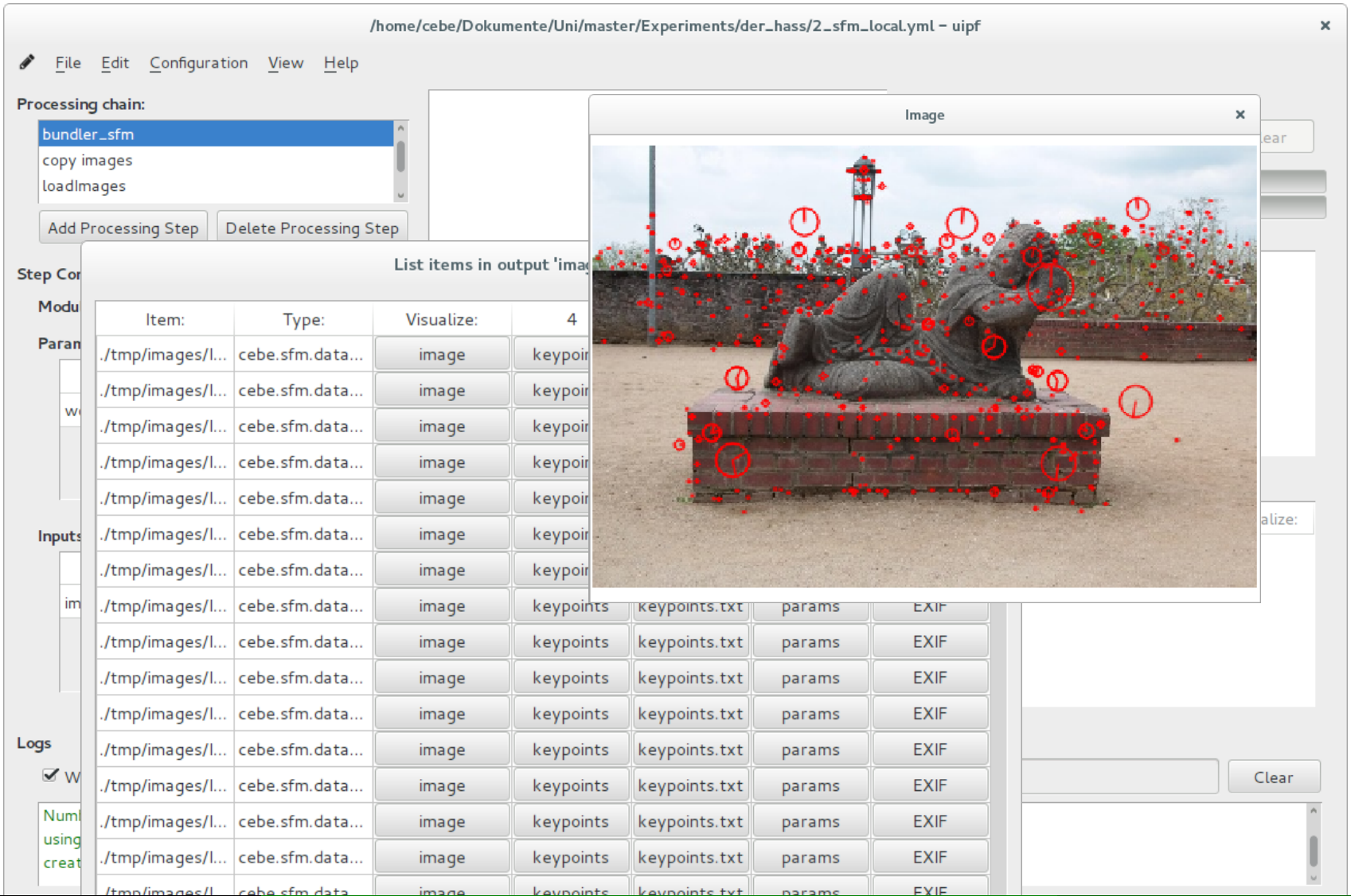
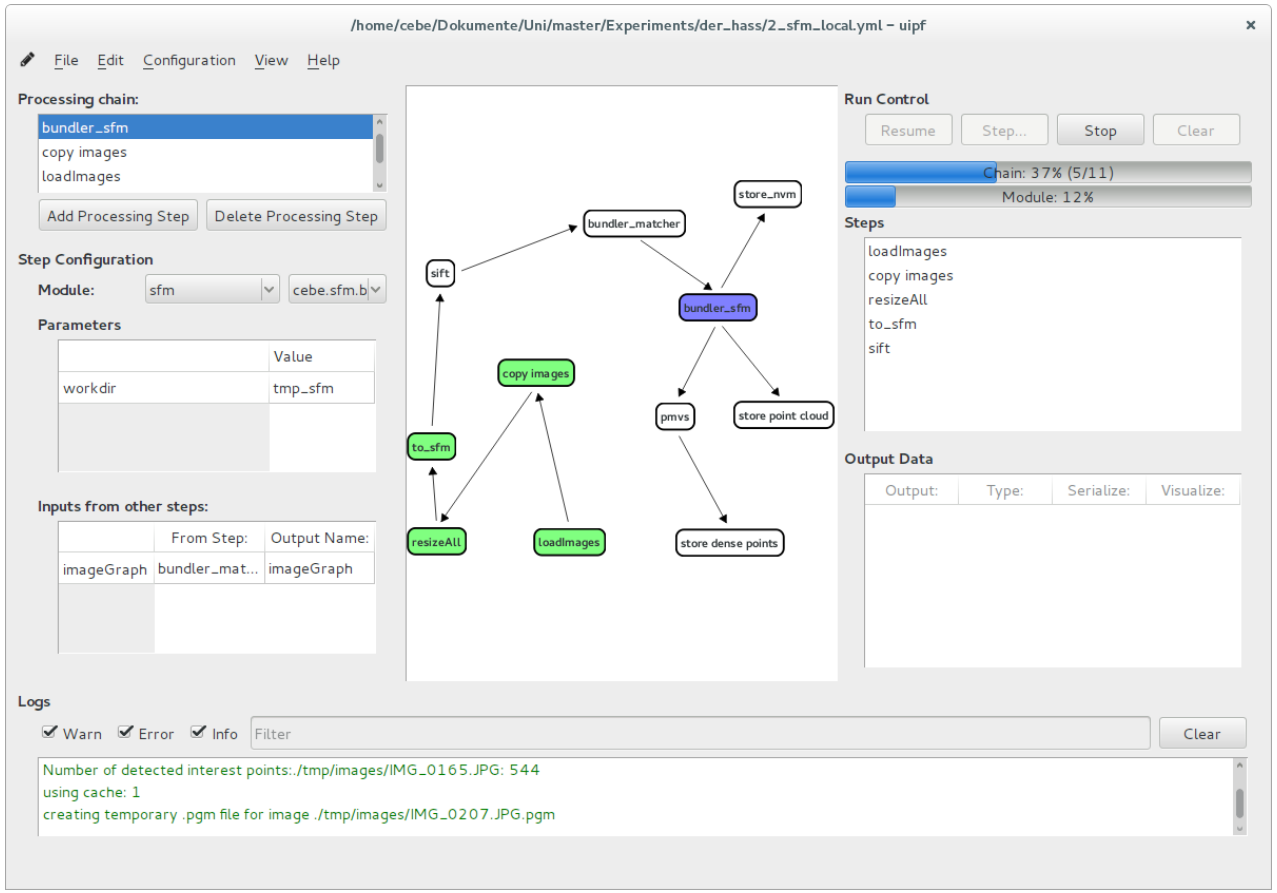


Sparse Point Cloud

Mesh

Conclusion


/home/cebe/Dokumente/Uni/master/Experiments/der_hass/2_sfm_local.yml – uipf
File
Edit
Configuration
View
Help
Processing chain:
bundler_sfm
copy images
loadImages
Add Processing Step
Delete Processing Step
Step Configuration
Module:
sfm
cebe.sfm.b
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tmp_sfm
Inputs from other steps:
From Step:
Output Name:
imageGraph
bundler_mat...
imageGraph
sift
bundler_matcher
store_nvm
bundler_sfm
copy images
pmvs
store point cloud
to_sfm
resizeAll
loadImages
store dense points
Run Control
Resume
Step...
Stop
Clear
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Module: 12%
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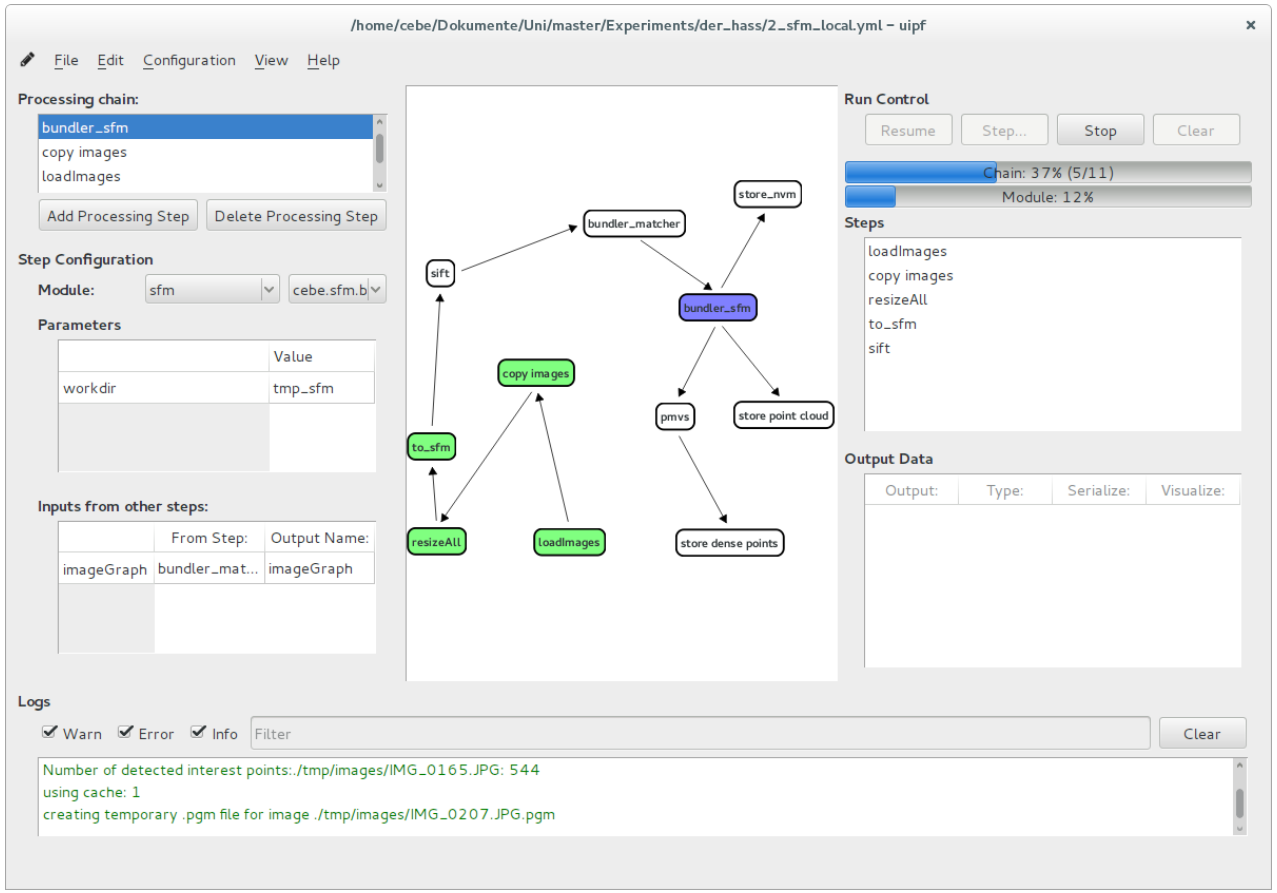
loadImages
copy images
resizeAll
to_sfm
sift
Output Data
Output:
Type:
Serialize:
Visualize:
Logs
Warn
Error
Info
Filter
Clear
Number of detected interest points:./tmp/images/IMG_0165.JPG: 544
using cache: 1
creating temporary .pgm file for image ./tmp/images/IMG_0207.JPG.pgm

Conclusion



https://github.com/uipf/uipf