

# Multi-GPU Based Image Feature Matching

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# Challenge Description



RamHacks is a 24-hours hackathon event host by Computer Science Department in the beginning of fall semester. You can choose different challenges provided by the cooperated companies.



## Detect the Sub-Image! from Elephant Insurance

### Description:

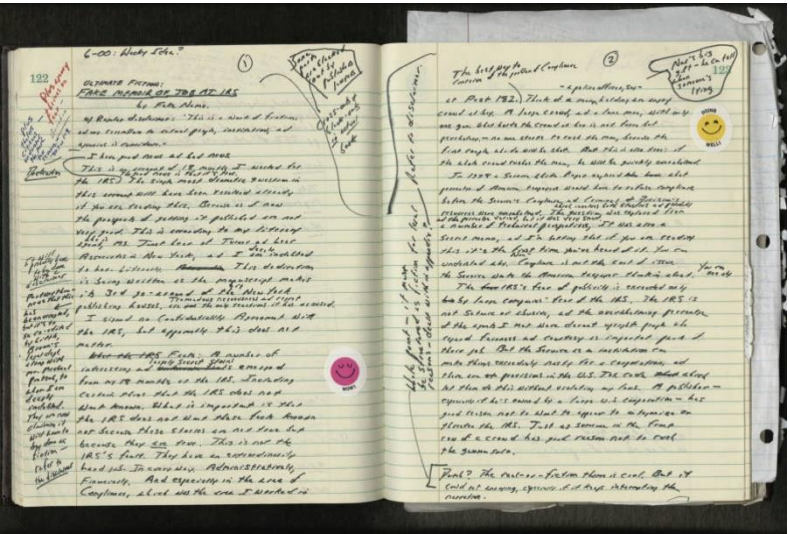
Given a sizeable list of both **images** and **sub-images**, **match** each sub-image with its corresponding image

### Judging Criteria:

- 1) Each sub-image must be **correctly** matched with the correct image
- 2) **The team that completes step #1 in the shortest amount of time will be the winner**

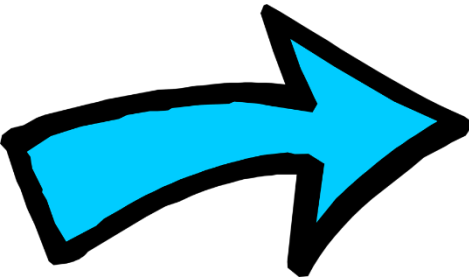
Source

Original image

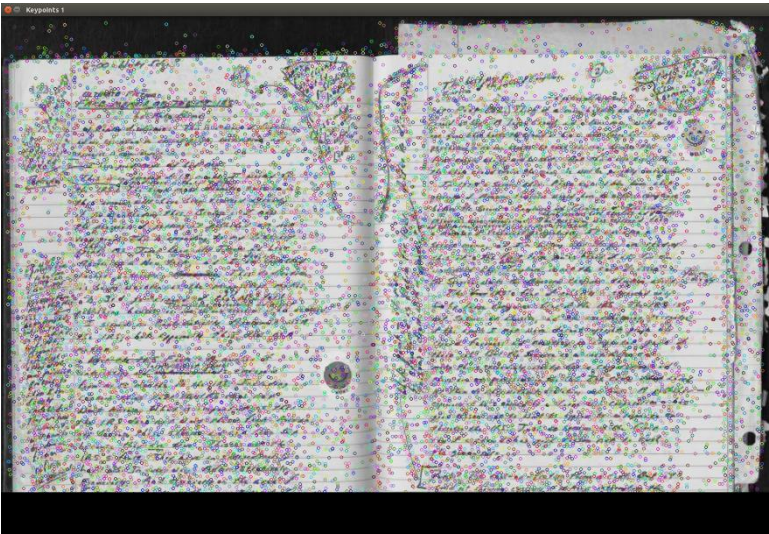


# Solution Example

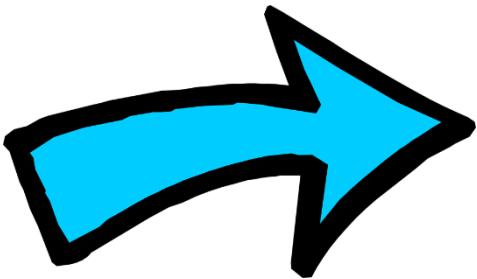
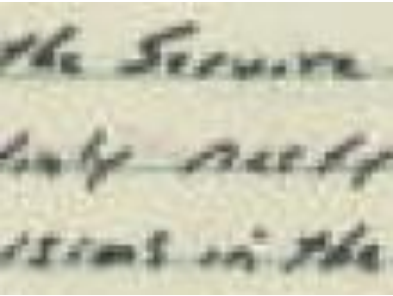
Step 1: Detect the keypoints using SURF Detector (Speeded-Up Robust Feature)



Feature Points



Target



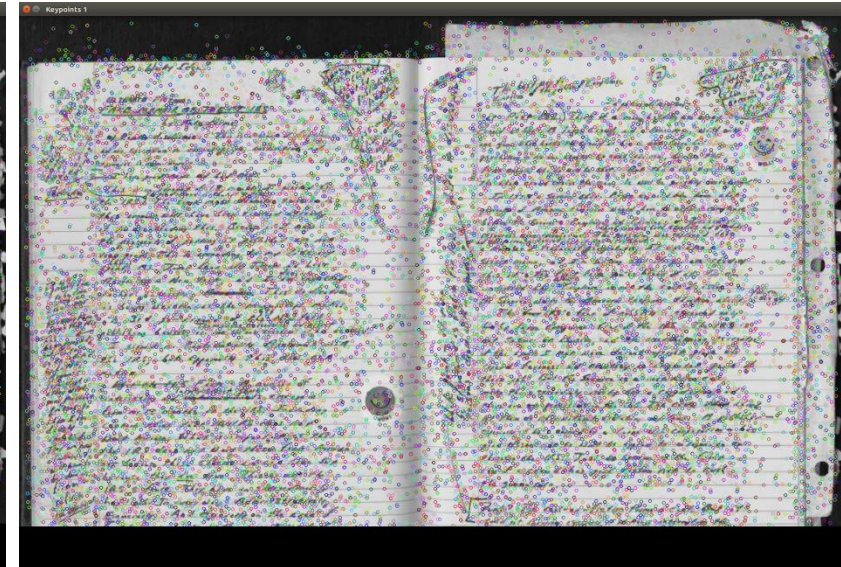
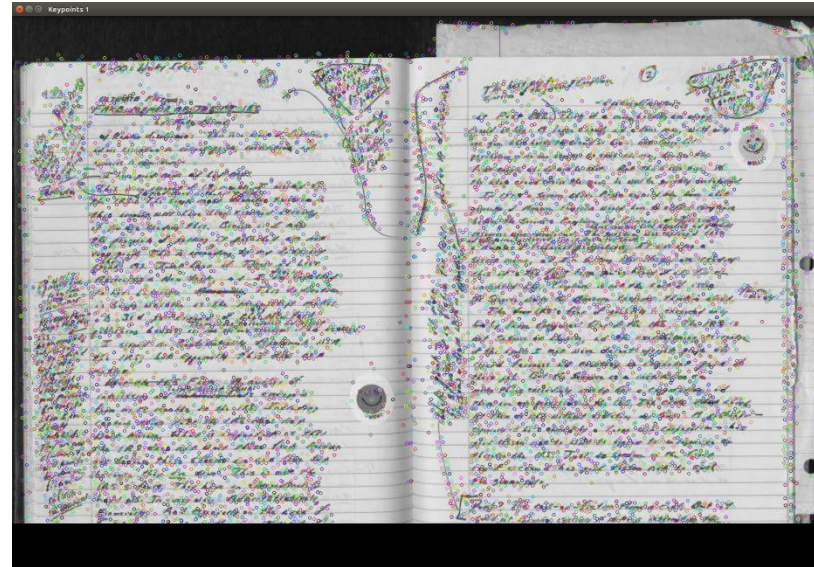
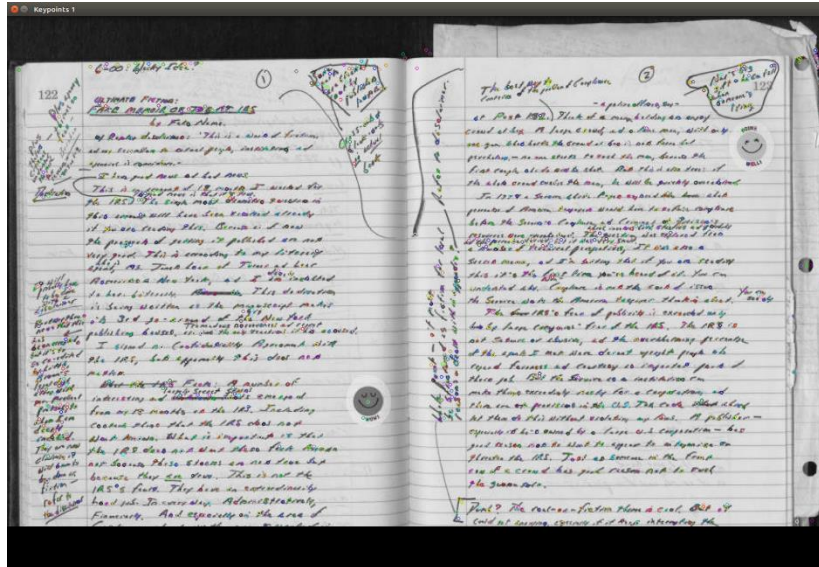


# Solution Example

Hessian = 4000

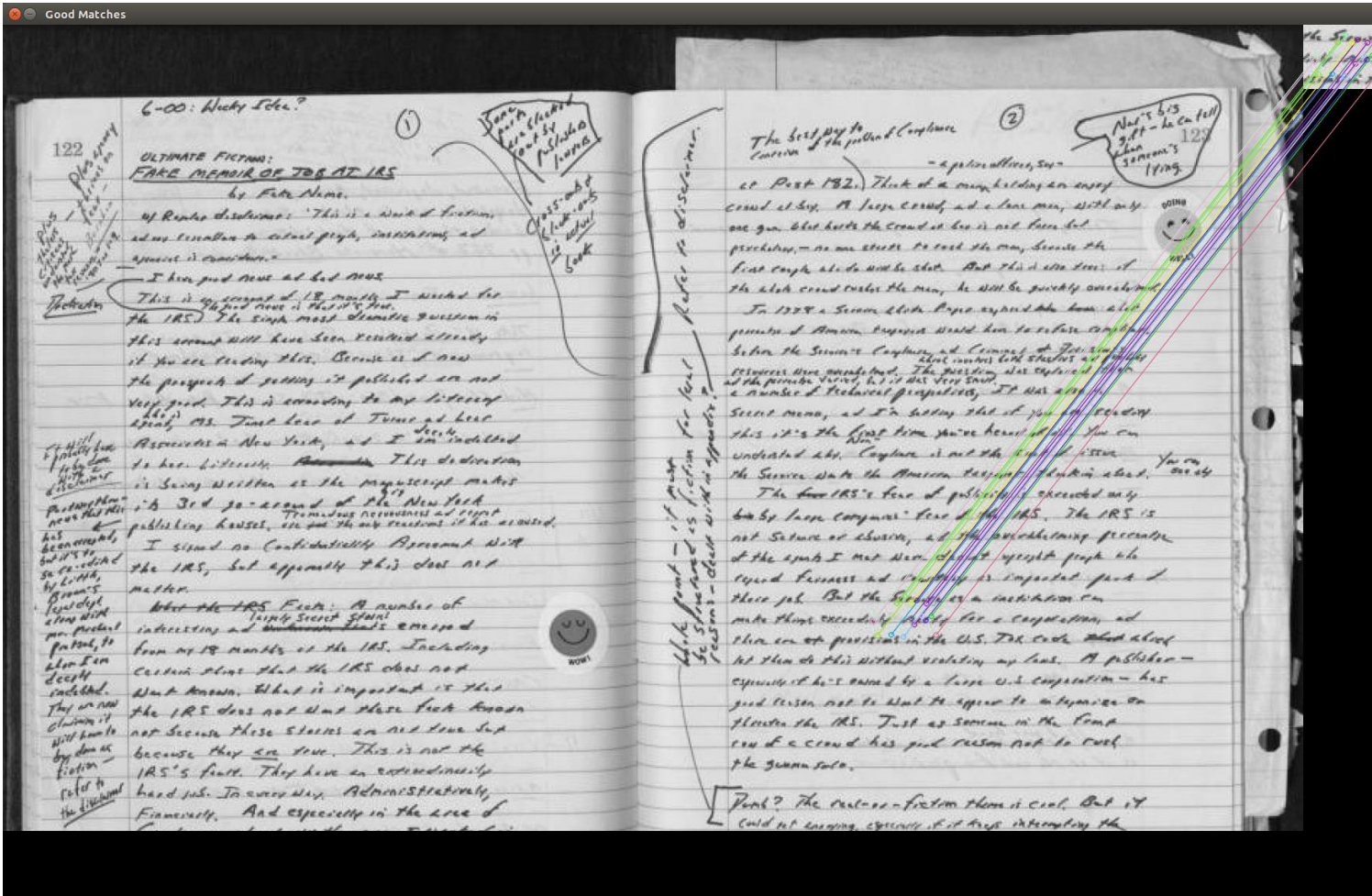
Hessian = 400

Hessian = 20





# Solution Example



Step 2: Calculate descriptors (feature vectors)

Step 3: Matching descriptor vectors using FLANN matcher (Fast Approximate Nearest Neighbor)

Draw "good" matches

001.jpg targets/tl1g.png

```

1: 326 -- Keypoint 2: 0 Distance is --->[0.016375]
1: 808 -- Keypoint 2: 1 Distance is --->[0.026425]
1: 1221 -- Keypoint 2: 2 Distance is --->[0.009091]
1: 1472 -- Keypoint 2: 4 Distance is --->[0.022217]
1: 1783 -- Keypoint 2: 5 Distance is --->[0.023945]
1: 2361 -- Keypoint 2: 6 Distance is --->[0.015588]
1: 3490 -- Keypoint 2: 10 Distance is --->[0.018050]
1: 3589 -- Keypoint 2: 11 Distance is --->[0.020033]
1: 4217 -- Keypoint 2: 14 Distance is --->[0.031488]
1: 4299 -- Keypoint 2: 15 Distance is --->[0.026511]
1: 4302 -- Keypoint 2: 16 Distance is --->[0.015079]
1: 5215 -- Keypoint 2: 18 Distance is --->[0.037988]
1: 5834 -- Keypoint 2: 21 Distance is --->[0.028173]
1: 6986 -- Keypoint 2: 28 Distance is --->[0.037034]
-- Good Match [14] Keypoint 1: 7391 -- Keypoint 2: 29 Distance is --->[0.025894]
-- Good Match [15] Keypoint 1: 8125 -- Keypoint 2: 33 Distance is --->[0.022121]
-- Good Match [16] Keypoint 1: 8545 -- Keypoint 2: 37 Distance is --->[0.020710]
    
```

6-00: Nucky Leta?

(1)

ULTIMATE FICTIO:  
FAKE MEMOIR OF TORGAT IRS  
by Fake Name.

of Ruckus disclaimers: "This is a work of fiction,  
and no intention to actual fight, instigating and  
aggravate it." "I have just now at last now  
this is my account of 18 months I worked for  
the IRS. The sixth most scientific question in  
this country will have been resolved already  
if you are reading this. Because as I was  
the prospect of getting it published are not  
very good. This is according to my biography  
that the final loss of Time has been  
Responsible in New York, and I am indebted  
to have written. ~~Remember~~ This document  
is being written as the manuscript makes  
it's job go around of the New York  
publishing houses, one put the only reviews if he wanted.  
I stand so confidently. Remembered that  
the IRS, but apparently they don't  
matter.

What the IRS Facts: A number of  
interesting and ~~unimportant~~ <sup>tiny secret story</sup> emerged  
from over 18 months in the IRS. Including  
certain thing that the IRS does not  
want known. What is important is that  
the IRS does not want those facts known  
not because those stories are not true but  
because they are true. This is not the  
IRS's fault. They have an extremely  
hard job. In every way. Administratively,  
Financially. And especially in the area of

(2)

The Secret Way to  
Control of the Federal Government  
- by Nelson Rockefeller, Esq. -  
et Post 1932. Think of a man holding an empty  
canister of gas. A large canister and a bare man, with only  
one gun. But holds the control in his hand. Then he  
proceeds, - no more threats to reach the man, forces the  
first cough and he will be silent. But this is also true of  
the which could control the man, he will be quickly overwhelmed.  
In 1937 a Senator wrote. People say that the man who  
governs the American taxpayer should have to refuse compliance  
before the Senate's Committee and Congress. At the same time  
financials were established. The question was whether there  
at the present time, but it was very hard  
a number of financial perspectives. It was also a  
Secret money, and it's history that if you are reading  
this it's the first time you've heard of it. You can  
understand why. Compliance is also the best of issues.  
The Senate wants the American taxpayer thinking about.  
The two IRS's force of publicity is executed only  
but by large companies, force of the IRS. The IRS is  
not secure or efficient, and the overwhelming percentage  
of the agents I met were Secret agents push the  
agent. Envy and Envy is an important part of  
these jobs. But the Service is a institution. I'm  
make them secondary really for a corporation, and  
then up its position in the U.S. The fact that along  
let them do their without violating any law. A politician -  
especially if he's owned by a large U.S. corporation - has  
good reason not to let it appear to interfere in  
favoring the IRS. Just as someone in the front  
row of a crowd has good reason not to rock  
the gunman's side.

Pink? The rule-of-fiction then is cool. But it  
could be a serious concern to the government.

Handwritten notes and drawings include:

- A diagram showing a person sitting at a desk with a lamp, labeled "Nucky Leta".
- A drawing of a person's head with a thought bubble containing "Nucky Leta".
- A drawing of a person's head with a thought bubble containing "Nucky Leta".
- A drawing of a person's head with a thought bubble containing "Nucky Leta".

```

Max dist : 1.168203
Min dist : 0.078705

Good Match [0] Keypoint 1: 8915 -- Keypoint 2: 92 Distance is --->[0.110467]
Good Match [1] Keypoint 1: 9366 -- Keypoint 2: 175 Distance is --->[0.117658]
Good Match [2] Keypoint 1: 9762 -- Keypoint 2: 123 Distance is --->[0.116964]
Good Match [3] Keypoint 1: 10215 -- Keypoint 2: 156 Distance is --->[0.118042]
Good Match [4] Keypoint 1: 10480 -- Keypoint 2: 92 Distance is --->[0.093637]
Good Match [5] Keypoint 1: 10552 -- Keypoint 2: 92 Distance is --->[0.102400]
Good Match [6] Keypoint 1: 10881 -- Keypoint 2: 224 Distance is --->[0.106838]
Good Match [7] Keypoint 1: 11318 -- Keypoint 2: 156 Distance is --->[0.107603]
Good Match [8] Keypoint 1: 11377 -- Keypoint 2: 60 Distance is --->[0.113093]
Good Match [9] Keypoint 1: 11513 -- Keypoint 2: 178 Distance is --->[0.110116]
Good Match [10] Keypoint 1: 11681 -- Keypoint 2: 203 Distance is --->[0.117366]
Good Match [11] Keypoint 1: 11716 -- Keypoint 2: 156 Distance is --->[0.110954]
Good Match [12] Keypoint 1: 11801 -- Keypoint 2: 178 Distance is --->[0.092611]
Good Match [13] Keypoint 1: 11819 -- Keypoint 2: 151 Distance is --->[0.117813]
Good Match [14] Keypoint 1: 11851 -- Keypoint 2: 102 Distance is --->[0.115129]
Good Match [15] Keypoint 1: 11852 -- Keypoint 2: 259 Distance is --->[0.114415]
Good Match [16] Keypoint 1: 11866 -- Keypoint 2: 259 Distance is --->[0.106765]
Good Match [17] Keypoint 1: 11892 -- Keypoint 2: 156 Distance is --->[0.117420]
Good Match [18] Keypoint 1: 12175 -- Keypoint 2: 178 Distance is --->[0.097669]
Good Match [19] Keypoint 1: 12256 -- Keypoint 2: 156 Distance is --->[0.114888]
Good Match [20] Keypoint 1: 12523 -- Keypoint 2: 60 Distance is --->[0.102087]
Good Match [21] Keypoint 1: 12526 -- Keypoint 2: 121 Distance is --->[0.101969]
Good Match [22] Keypoint 1: 12744 -- Keypoint 2: 297 Distance is --->[0.104380]
Good Match [23] Keypoint 1: 12859 -- Keypoint 2: 203 Distance is --->[0.114262]
Good Match [24] Keypoint 1: 13207 -- Keypoint 2: 186 Distance is --->[0.087274]
Good Match [25] Keypoint 1: 13350 -- Keypoint 2: 150 Distance is --->[0.116417]
Good Match [26] Keypoint 1: 13351 -- Keypoint 2: 149 Distance is --->[0.113027]
Good Match [27] Keypoint 1: 13922 -- Keypoint 2: 178 Distance is --->[0.107390]
Good Match [28] Keypoint 1: 13975 -- Keypoint 2: 123 Distance is --->[0.117161]
Good Match [29] Keypoint 1: 14078 -- Keypoint 2: 147 Distance is --->[0.116340]
Good Match [30] Keypoint 1: 14162 -- Keypoint 2: 257 Distance is --->[0.096141]
Good Match [31] Keypoint 1: 14205 -- Keypoint 2: 178 Distance is --->[0.115316]
Good Match [32] Keypoint 1: 14233 -- Keypoint 2: 257 Distance is --->[0.098703]
Good Match [33] Keypoint 1: 14290 -- Keypoint 2: 297 Distance is --->[0.115477]
Good Match [34] Keypoint 1: 14320 -- Keypoint 2: 259 Distance is --->[0.089134]
Good Match [35] Keypoint 1: 14348 -- Keypoint 2: 184 Distance is --->[0.113099]
Good Match [36] Keypoint 1: 14384 -- Keypoint 2: 259 Distance is --->[0.103156]
Good Match [37] Keypoint 1: 15214 -- Keypoint 2: 155 Distance is --->[0.084438]
Good Match [38] Keypoint 1: 15307 -- Keypoint 2: 155 Distance is --->[0.111654]
Good Match [39] Keypoint 1: 15316 -- Keypoint 2: 257 Distance is --->[0.104241]
Good Match [40] Keypoint 1: 15326 -- Keypoint 2: 151 Distance is --->[0.094454]
Good Match [41] Keypoint 1: 15470 -- Keypoint 2: 297 Distance is --->[0.098348]
Good Match [42] Keypoint 1: 15542 -- Keypoint 2: 161 Distance is --->[0.107558]
Good Match [43] Keypoint 1: 15560 -- Keypoint 2: 297 Distance is --->[0.117391]
Good Match [44] Keypoint 1: 15770 -- Keypoint 2: 155 Distance is --->[0.101258]
Good Match [45] Keypoint 1: 15801 -- Keypoint 2: 155 Distance is --->[0.114543]
Good Match [46] Keypoint 1: 16075 -- Keypoint 2: 257 Distance is --->[0.078705]
Good Match [47] Keypoint 1: 16209 -- Keypoint 2: 163 Distance is --->[0.101063]
Good Match [48] Keypoint 1: 16298 -- Keypoint 2: 214 Distance is --->[0.107227]
Good Match [49] Keypoint 1: 16426 -- Keypoint 2: 257 Distance is --->[0.095014]
Good Match [50] Keypoint 1: 16502 -- Keypoint 2: 257 Distance is --->[0.104689]
Good Match [51] Keypoint 1: 16598 -- Keypoint 2: 123 Distance is --->[0.116257]
Good Match [52] Keypoint 1: 16845 -- Keypoint 2: 257 Distance is --->[0.115389]
Good Match [53] Keypoint 1: 17057 -- Keypoint 2: 123 Distance is --->[0.114779]
Good Match [54] Keypoint 1: 17173 -- Keypoint 2: 161 Distance is --->[0.113397]
Good Match [55] Keypoint 1: 17177 -- Keypoint 2: 161 Distance is --->[0.115474]
Good Match [56] Keypoint 1: 17411 -- Keypoint 2: 297 Distance is --->[0.107898]
Good Match [57] Keypoint 1: 17568 -- Keypoint 2: 178 Distance is --->[0.116021]
Good Match [58] Keypoint 1: 17785 -- Keypoint 2: 175 Distance is --->[0.115829]
Good Match [59] Keypoint 1: 17947 -- Keypoint 2: 297 Distance is --->[0.107388]
Good Match [60] Keypoint 1: 18174 -- Keypoint 2: 123 Distance is --->[0.114521]
Good Match [61] Keypoint 1: 18456 -- Keypoint 2: 246 Distance is --->[0.110421]
Good Match [62] Keypoint 1: 18458 -- Keypoint 2: 123 Distance is --->[0.112466]
Good Match [63] Keypoint 1: 18650 -- Keypoint 2: 297 Distance is --->[0.108819]
Good Match [64] Keypoint 1: 19650 -- Keypoint 2: 297 Distance is --->[0.117456]

```



# Algorithm Analysis

- 1. Upload image
- 2. Calculate the **Keypoints**
- 3. Calculate the **Descriptors**
- 4. Matching using **FLANN matcher**



# Original Program

- For ( Source Image)

Upload **source image**

Calculate the **source Keypoints**

Calculate the **source Descriptors**

- For(Target Image)

Upload **Target image**

Calculate the **Target Keypoints**

Calculate the **Target Descriptors**

**FLANN matcher** (Target Descriptors, **source Descriptors**)

Complexity  $n * n$

Performance

Mean(micro S)	Std	Speedup
44591511219.2	294957108.	1

Redundant

# Methods to Improve Performance

- 1. Better Coding
- 2. Multi-Thread
- 3. Single GPU
- 4. Multi-GPU

# Better Coding

For ( Source Image)

Upload **source image**

Calculate the **source Keypoints**

Calculate the **source Descriptors**

**Save the Descriptors to memory**

More Memory  
Needed

For ( Target Image)

Upload **target image**

Calculate the **target Keypoints**

Calculate the **target Descriptors**

**Save the Descriptors to memory**

## Performance

Mean(micro S)	Std	Speedup
18333352721.7	95949909	1
1327316537.5	12260675	<b>13.81</b>

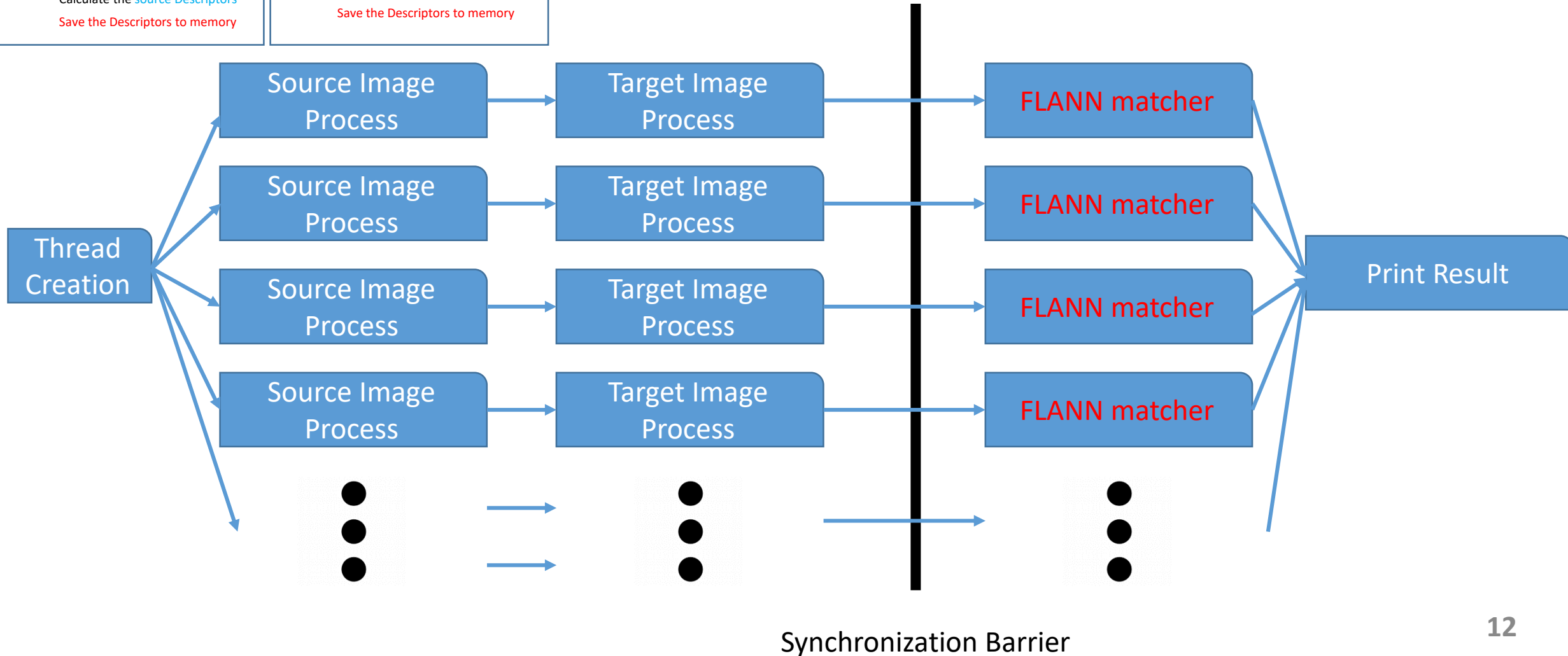
**FLANN matcher** (Target Descriptors, **source Descriptors**)



# Multi-Thread

For ( Source Image)  
Upload **source image**  
Calculate the **source Keypoints**  
Calculate the **source Descriptors**  
Save the Descriptors to memory

For ( Target Image)  
Upload **target image**  
Calculate the **target Keypoints**  
Calculate the **target Descriptors**  
Save the Descriptors to memory



# Multi-Thread

- Task decomposition
- Number of task depends on number of pictures
- Pthread has been used to implement multi thread

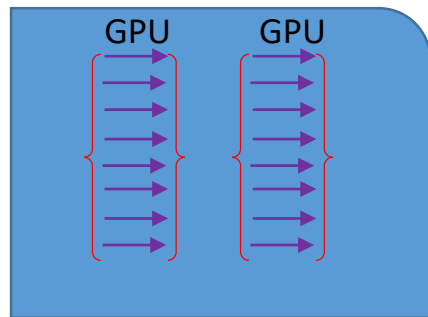
## Performance

Mean(micro S)	Std	Speedup
18333352721.7	95949909	1
1327316537.5	12260675	13.81
144935912.6 *	7677366	126.49

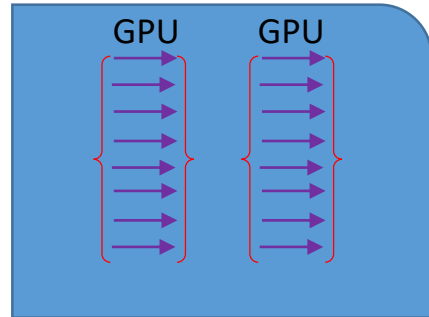
\*Result based on 20 thread

# Single GPU

- 1. Calculate the Keypoints -----→ GPU
- 2. Calculate the Descriptors -----→ GPU
- 3. Matching using FLANN matcher -----→ GPU



Source Image Process



Target Image Process

Mean(micro S)	Std	Speedup
18333352721.7	95949909	1
1327316537.5	12260675	13.81
144935912.6 *	7677366	126.49
28056436 **	797203	653.44

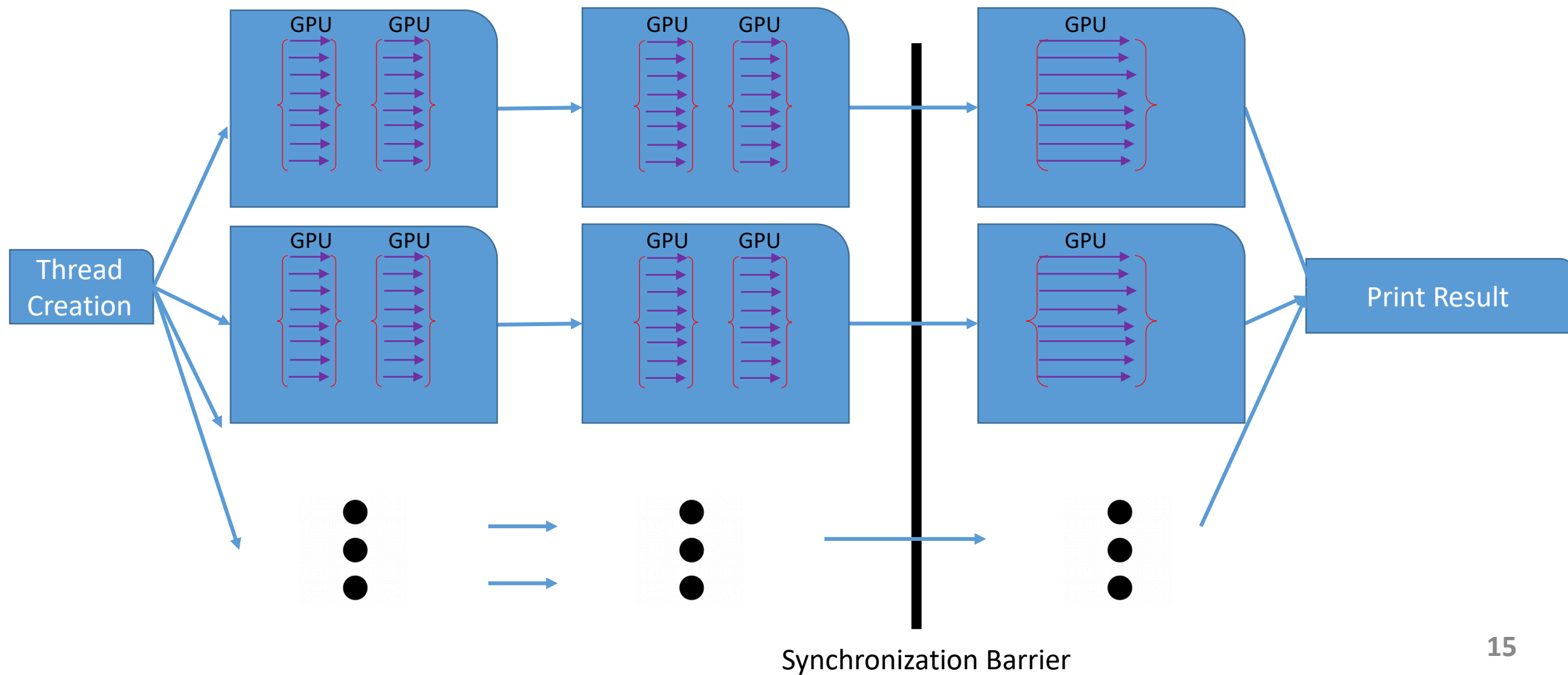
\*Result based on 20 thread

\*\*GeForce GTX TITAN X

Target Image Process



# Multi-GUP



# Result

Mean(micro S)	Std	Speedup
18333352721.7 (5.1 hours)	95949909	1
1327316537.5 (22.1 minutes)	12260675	13.81
144935912.6 * (2.4 minutes)	7677366	126.49
28056436 ** (28 seconds)	797203	653.44
16347417.5*** (16 seconds)	415412	1121.48

\* Result based on 20 thread

\*\* GeForce GTX TITAN X

\*\*\* 7GUP have been used

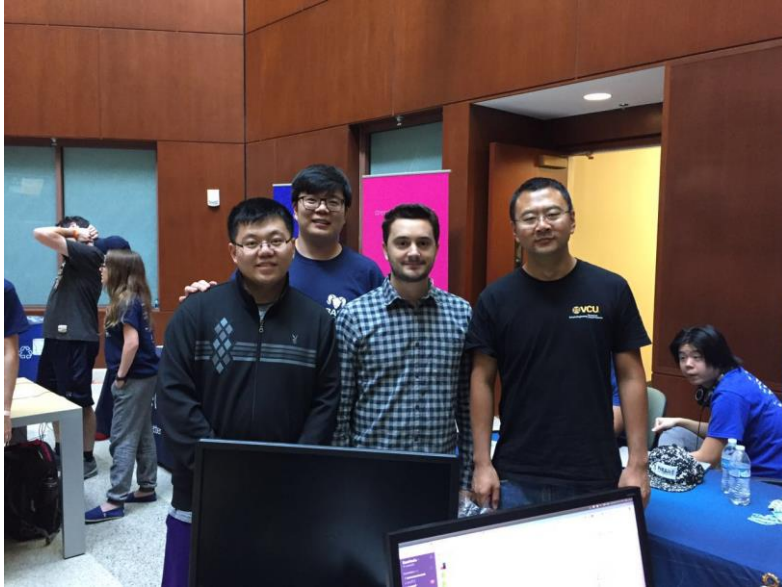
# Future Work

- 1. Balance Work between thread. Different image have different size.
- 2. Better use the CPU and GPU memory system .





# Acknowledgement



The Original Code was developed during the RamHack in 24 hours.  
Directed by Dr. Cano

Group Member:

Dongwei Wang

Mo Li

Liang Xu