**Face detection**

**Project**

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Images to work with from the FEI Face database (https://fei.edu.br/~cet/facedatabase.html)

2-11



3-11



4-11



5-11



*Please note these two examples below, the first one exhibits standard behavior, while the second one does not.*

Consider these 4 binary layers:

The zeroth binary layer selects pixels mainly concentrated along the contours of the skin and hair areas.
The first binary layer selects pixels from the outer regions of the skin area and eyebrows.
The second binary layer selects pixels from the inner regions of the skin area.
The third binary layer selects pixels from the central region.

Above are represented different images with several modifications. The left-most image of all 6 is the original one, following is an image to which binary layer 0 is applied, then the one to which binary layer 1 is applied, then binary layer 2 and finally, the right-most image is the one to which binary layer 3 is applied.

Based on the examples, we can see that from the photos assigned to me, 2-11 and 4-11 exhibit the standard behavior, but 3-11 and 5-11 do not.

Characteristics of *the standard behavior*:

- Zeroth binary layer selects pixels mainly concentrated along the face bounds.
- First binary layer selects the majority of the skin pixels,
- Second binary layer selects pixels from the central region around the nose, eyebrows and lips.
- Third binary layer selects pixels from the lips and, possible, ears.

Characteristics of the *not standard behavior*:

- Zeroth binary layer extracts practically all skin pixels, instead of the border pixels.
- First binary layer extracts some pixels around the nostrils, lips and eye sockets.
- Second binary layer concentrates on the lips.
- Third binary layer concentrates on the lips as well.

Stage 1.1

The task is to produce smoothened and prominent regions and minimize or remove insignificant details. In order to reach so we should consider different filters of different radii and apply before and/or after the extraction of the Binary Layers.

* The command from ImageJ **Process** ▷ **Filters** sub-menu is used.

Image 2-11



Consider 2-11 and the zeroth binary layer applied.

*After extraction of Binary layer 0*

1.  Binary layer 0, Gaussian blur 1

    

2.  Binary layer 0, Gaussian blur 1, Median 2

    

3.  Binary layer 0, Gaussian blur 2, Maximum 1

    

4. Binary layer 0, Gaussian blur 1, Minimum 1



5. Binary layer 0, Minimum 1, Median 2, Maximum 1



6. *Binary layer 0, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*



7. Binary layer 0, Gaussian blur 1, Minimum 2, Median 2

## 8. *Binary layer 0, Gaussian blur 1, Median 4*

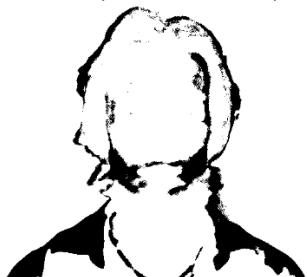

*Before extraction of binary layer 0*

## 9. Gaussian blur 1, Binary layer 0



## 10. *Gaussian blur 1, Median 3, Binary layer 0*



## 11. *Median 3, Minimum 1, Gaussian blur 2, Binary layer 0*

### 12. Median 4, Gaussian blur 3, Maximum 2, Binary layer 0, Minimum 0.5



### 13. Gaussian blur 2, Binary layer 0, Median 3



### 14. Mean 2, Binary layer 0, Minimum 1, Gaussian blur 1



### 15. Median 4, Binary layer 0, Gaussian blur 1.5

Consider 2-11 and the first binary layer applied.

*After extraction of Binary layer 1*

1. Binary layer 1, Gaussian blur 1, Median 2



2. Binary layer 1, Gaussian blur 1, Minimum 1



3. ***Binary layer 1, Gaussian blur 1, Minimum 2, Median 4, Maximum 1***



4. ***Binary layer 1, Gaussian blur 1, Minimum 1, Median 4***

5. Binary layer 1, Median 2, Median 3, Minimum 1



6. *Binary layer 1, Gaussian blur 1, Median 4*



7. Binary layer 1, Gaussian blur 1, Minimum 2, Median 2



8. *Binary layer 1, Mean 2, Minimum 1*

*Before extraction of binary layer 1*

9.  Gaussian blur 1, Median 3, Binary layer 1



**10.  Median 3, Minimum 1, Gaussian blur 2, Binary layer 1**



11. Mean 2.5, Median 1.5, Binary layer 1

12. ***Median 4, Gaussian blur 3, Maximum 2, Binary layer 1, Minimum 0.5***



13. Gaussian blur 2, Binary layer 1, Maximum 2.



   -interesting case- left eye is vanished

14. ***Median 4, Binary layer 1, Gaussian blur 1.5***



15. ***Mean 2, Binary layer 1, Minimum 1, Gaussian blur 1***

Consider 2-11 and the second binary layer applied.

*After extraction of Binary layer 2*

1. Binary layer 2, Gaussian blur 1.5, Minimum 1



2. *Binary layer 2, Gaussian blur 0.5, Mean 1*



3. *Binary layer 2, Gaussian blur 1, Median 4*

*4.* Binary layer 2, Gaussian blur 0.7, Minimum 1, Median 3



5. Binary layer 2, Mean 2, Minimum 1, Maximum 0.5



*6. Binary layer 2, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*

7. ***Median 3, Minimum 1, Gaussian blur 2, Binary layer 2***



8. Mean 2.5, Median 1.5, Binary layer 2



9. ***Minimum 1.5, Median 3.25, Maximum 1.5, Mean 2, Binary layer 2***

*Before AND after extraction of binary layer 2*

10. Median 4, Gaussian blur 3, Maximum 2, Binary layer 2, Minimum 0.5

-interesting case- the structure of the lip is changes because of the Max filter application

11. ***Mean 2, Binary layer 2, Minimum 0.3, Gaussian blur 0.5***



12. Median 4, Binary layer 2, Gaussian blur 1

*13. Median 3, Mean 2.25, Binary layer 2, Gaussian blur 1.25, Maximum 2, Minimum 0.5*



14. Mean 2.3, Maximum 1.2, Binary layer 2, Gaussian blur 1, Maximum 0.3



-interesting case- notice the change in the structure of the lips and also notice the Max filter application

*15. Minimum 0.5, Binary layer 2, Mean 2.5*

Consider 2-11 and the third binary layer applied.

*After extraction of Binary layer 3*
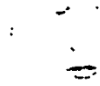
1. Binary layer 3, Gaussian blur 0.5, Mean 1 (animast)



2. ***Binary layer 3, Gaussian blur 1, Minimum 2, Median 4, Maximum 1***



3. ***Binary layer 1, Gaussian blur 1, Median 4***

4. Binary layer 3, Median 0.3, Minimum 0.6

5. *Binary layer 3, Gaussian blur 1, Minimum 1, Median 4*

6. *Binary layer 3, Mean 2, Minimum 1, Maximum 0.5*

*Before extraction of binary layer 3*

7. *Median 3, Minimum 1, Gaussian blur 2, Binary layer 3*

8. Minimum 3, Binary layer 3

-interesting case- the structure of the lips is changes here as well, however, as we can see it is because of the intense Minimum filter application

9. *Minimum 2.5, Maximum 0.5, Median 3, Binary layer 3*

10. Maximum 3, Median 2, Binary layer 3

-interesting case- the lips remind us a heart

**11.** Minimum 3.5, Maximum 1.5, Minimum 1, Binary layer 3 (similar to ***Minimum 2.5, Maximum 0.5, Median 3, Binary layer 3***)

-interesting fact – please refer to the mentioned case

*Before AND after extraction of binary layer 3*

12. Median 3, Minimum 1, Binary layer 3, Gaussian blur 1, Minimum 1

**13.** Median 3, Mean 2.25, Binary layer 3, Gaussian blur 1.25, Maximum 2, Minimum 0.5

**14. Median 4, Binary layer 0, Gaussian blur 1.5**

*15. Median 3, Binary layer 3, Minimum 2*



<span style="color:#b5651d">-important fact- please notice the intense Minimum filter effect which kind of thickened the lip outline</span>

## *Successful filter combinations for Binary layer 0*

6. <span style="color:red">***Binary layer 0, Gaussian blur 1, Minimum 2, Median 4, Maximum 1***</span>



8. <span style="color:red">***Binary layer 0, Gaussian blur 1, Median 4***</span>



10. *Gaussian blur 1, Median 3, Binary layer 0*



11. <span style="color:red">***Median 3, Minimum 1, Gaussian blur 2, Binary layer 0***</span>



12. <span style="color:#2e5c8a">*Median 4, Gaussian blur 3, Maximum 2, Binary layer 0, Minimum 0.5*</span>

*15. Median 4, Binary layer 0, Gaussian blur 1.5*



## Successful filter combinations for Binary layer 1

*3. Binary layer 1, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*



*4. Binary layer 1, Gaussian blur 1, Minimum 1, Median 4*



*6. Binary layer 1, Gaussian blur 1, Median 4*



**8.** *Binary layer 1, Mean 2, Minimum 1*



*10. Median 3, Minimum 1, Gaussian blur 2, Binary layer 1*

12. *Median 4, Gaussian blur 3, Maximum 2, Binary layer 1, Minimum 0.5*



14. *Median 4, Binary layer 1, Gaussian blur 1.5*



15. *Mean 2, Binary layer 1, Minimum 1, Gaussian blur 1*



## Successful filter combinations for Binary layer 2

2.*Binary layer 2, Gaussian blur 0.5, Mean 1*

3. *Binary layer 2, Gaussian blur 1, Median 4*



6. *Binary layer 2, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*



7. *Median 3, Minimum 1, Gaussian blur 2, Binary layer 2*



9. *Minimum 1.5, Median 3.25, Maximum 1.5, Mean 2, Binary layer 2*



11. *Mean 2, Binary layer 2, Minimum 0.3, Gaussian blur 0.5*

13. *Median 3, Mean 2.25, Binary layer 2, Gaussian blur 1.25, Maximum 2, Minimum 0.5*

15. *Minimum 0.5, Binary layer 2, Mean 2.5*

## *Successful filter combinations for Binary layer 3*

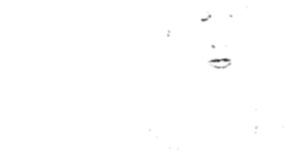2. *Binary layer 3, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*

3. *Binary layer 1, Gaussian blur 1, Median 4*

5. *Binary layer 3, Gaussian blur 1, Minimum 1, Median 4*

6. *Binary layer 3, Mean 2, Minimum 1, Maximum 0.5*

7. *Median 3, Minimum 1, Gaussian blur 2, Binary layer 3*

9. *Minimum 2.5, Maximum 0.5, Median 3, Binary layer 3*

14. *Median 4, Binary layer 0, Gaussian blur 1.5*

15. *Median 3, Binary layer 3, Minimum 2*

Please note that with RED COLOR we indicate the filter combinations that take part in all 4 modifications' successful filter combo list. And as we can see there 3 of them.

*Binary layer 3, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*

*Binary layer 1, Gaussian blur 1, Median 4*

*Median 3, Minimum 1, Gaussian blur 2, Binary layer 3*

With GREEN COLOR we indicate the filter combination that takes part in 3 modifications: Binary layer 0's, Binary layer 1's and Binary layer 3's.

*Median 4, Binary layer 0, Gaussian blur 1.5*

With BLUE COLOR we indicate the filter combination that takes part in 2 modifications:

Binary layer 0's and Binary layer 1's.

*Median 4, Gaussian blur 3, Maximum 2, Binary layer 0, Minimum 0.5*

With YELLOWISH COLOR we indicate the filter combination that takes part in 2 other modifications:  Binary layer 1's and Binary layer 3's.

*Binary layer 3, Gaussian blur 1, Minimum 1, Median 4*

Please also notice interesting cases and an important fact inside the trials above.

From 60 tries, 15 for each layer, respectively, 30 worked successfullish, where

6/15 for Binary layer 0

8/15 for Binary layer 1

8/15 for Binary layer 2

8/15 for Binary layer 3

In order to find the best combination for the photo itself, we should take into consideration all fair filter combinations for every Binary layer and take intersections of the chosen filter combos.

Therefore, from the small statistics above, for 2-11 image we will choose filter combos with RED COLOR, i.e.

*Binary layer 3, Gaussian blur 1, Minimum 2, Median 4, Maximum 1*

*Binary layer 1, Gaussian blur 1, Median 4*

*Median 3, Minimum 1, Gaussian blur 2, Binary layer 3*