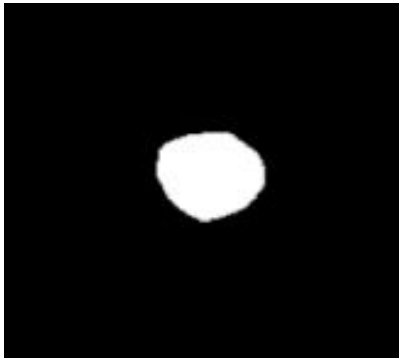
MEDICAL IMAGE SEGMENTATION USING CNN AND DYNAMIC PROGRAMMING

Nilabjanayan Bera

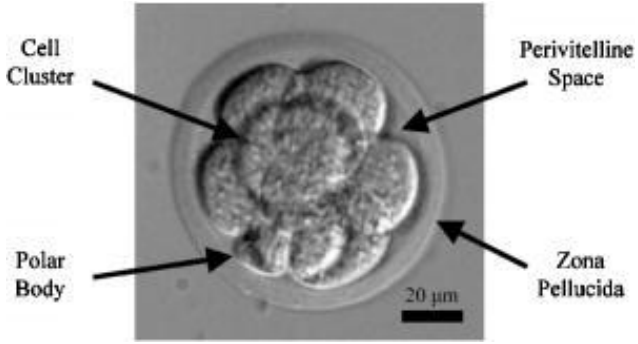




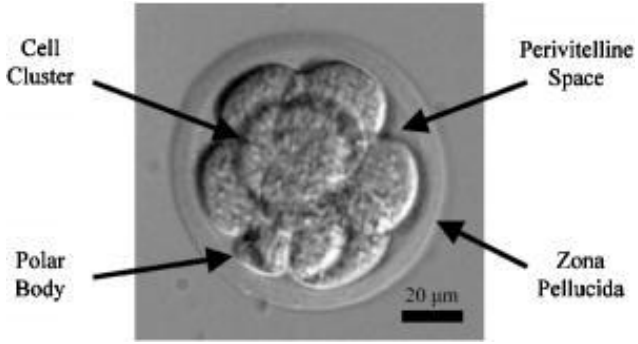
Medical Segmentation Tasks : Lack of Training Data

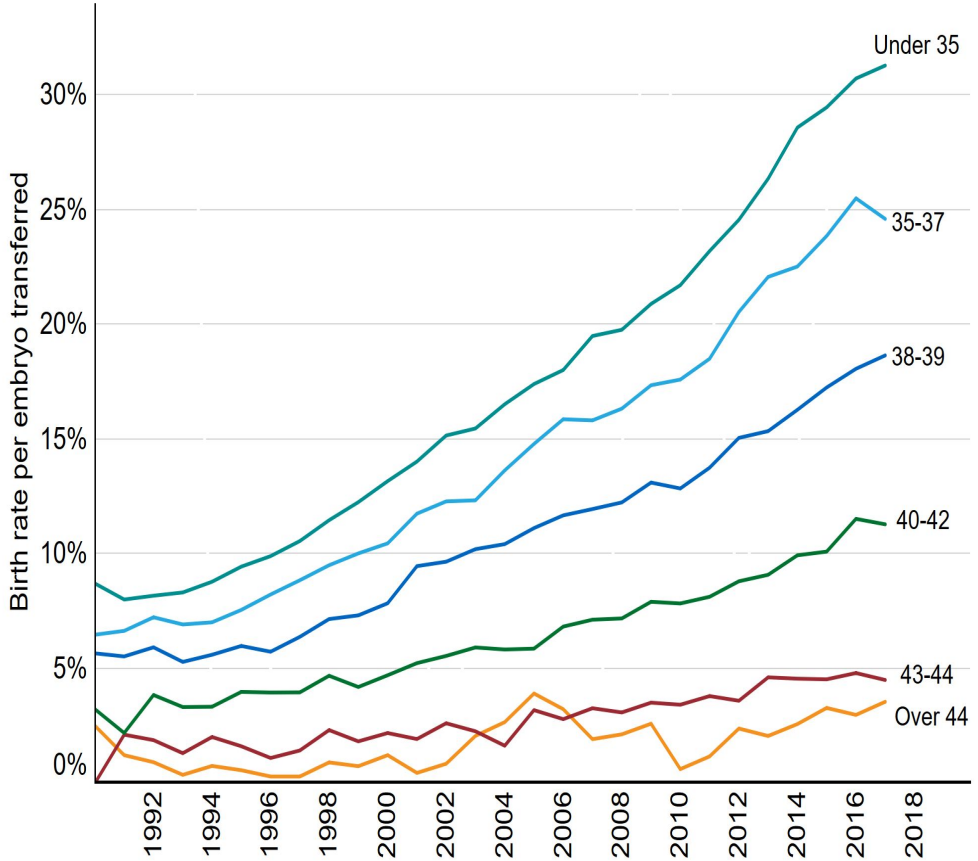


CASE - I

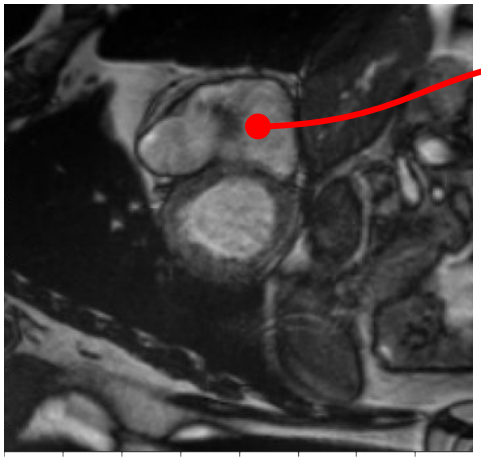

Cell
Cluster
Perivitelline
Space
Polar
Body
Zona
Pellucida
20 µm

CASE - I

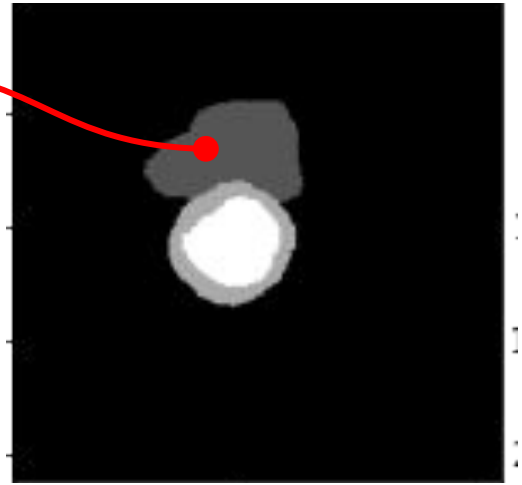

Cell Cluster
Perivitelline Space
Polar Body
Zona Pellucida
20 µm


Birth rate per embryo transferred
30%
25%
20%
15%
10%
5%
0%
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Under 35
35-37
38-39
40-42
43-44
Over 44

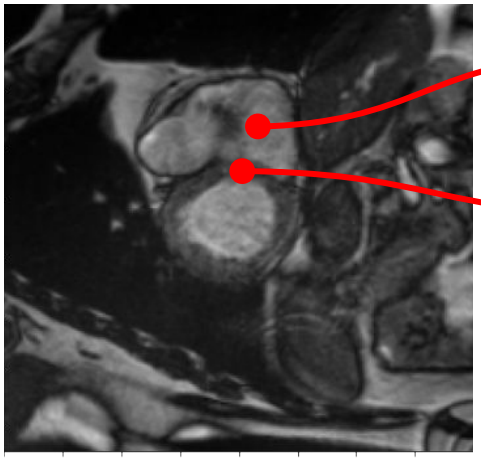
CASE - II



Right Ventricle

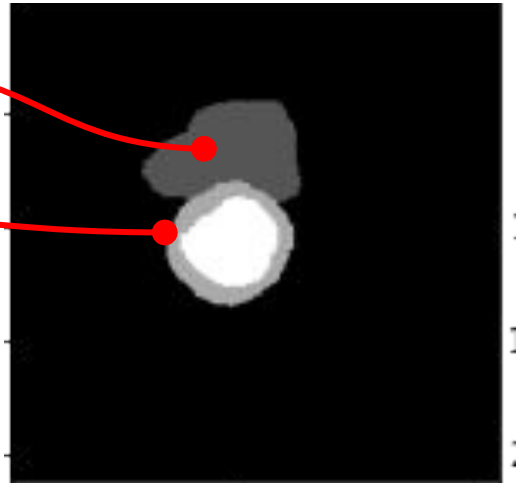


CASE - II

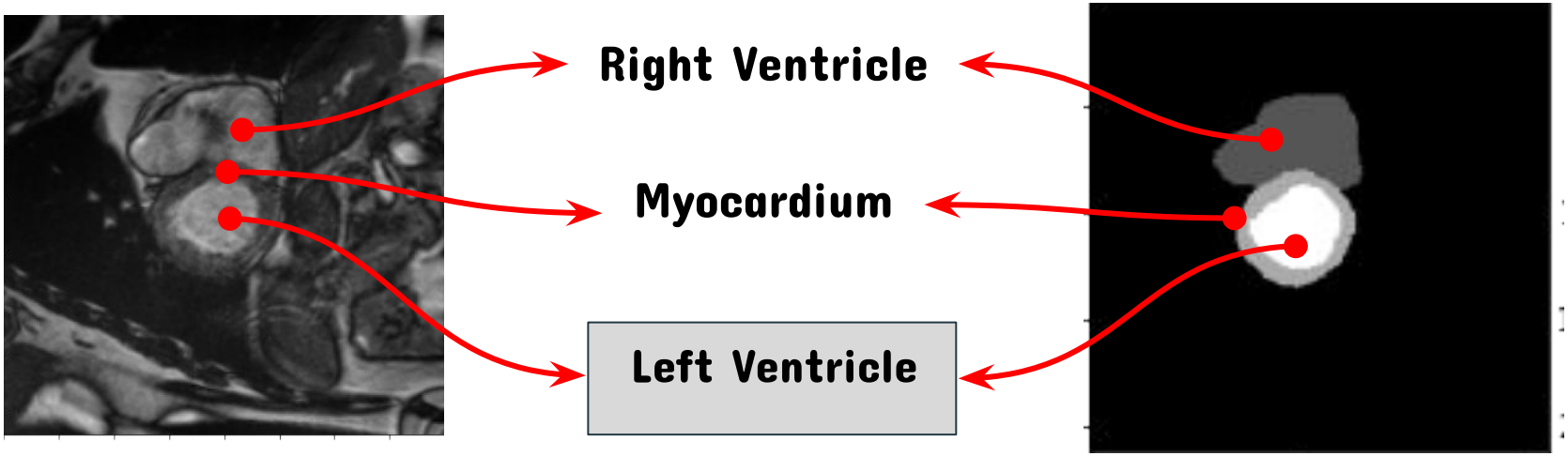


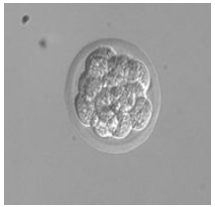
Right Ventricle

Myocardium



CASE - II



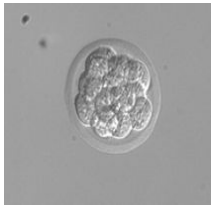


(640, 480)

Nikon Eclipse TE200 microscope with a 20x, 0.45 NA objective lens and a 0.52 NA condenser lens

Training : 12

Testing : 3



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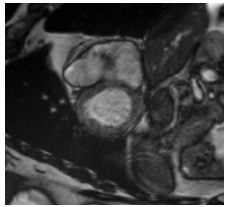
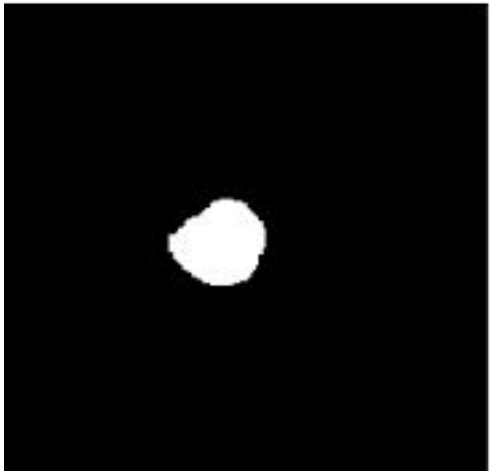
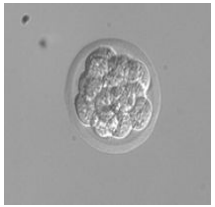




Training : 1516

Testing : 386



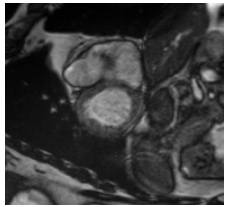
(640, 480)

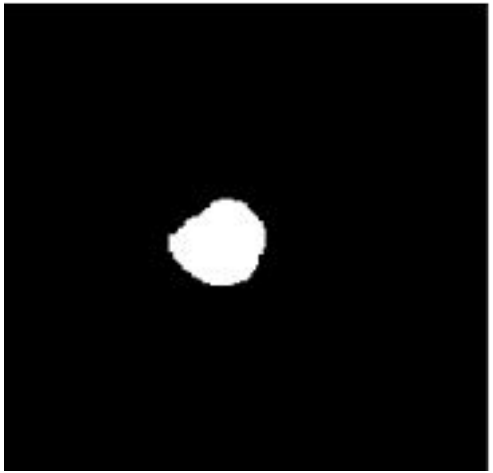
Nikon Eclipse TE200 microscope with a 20x, 0.45 NA objective lens and a 0.52 NA condenser lens

Training : 12

Testing : 3

Small no. of training data!!

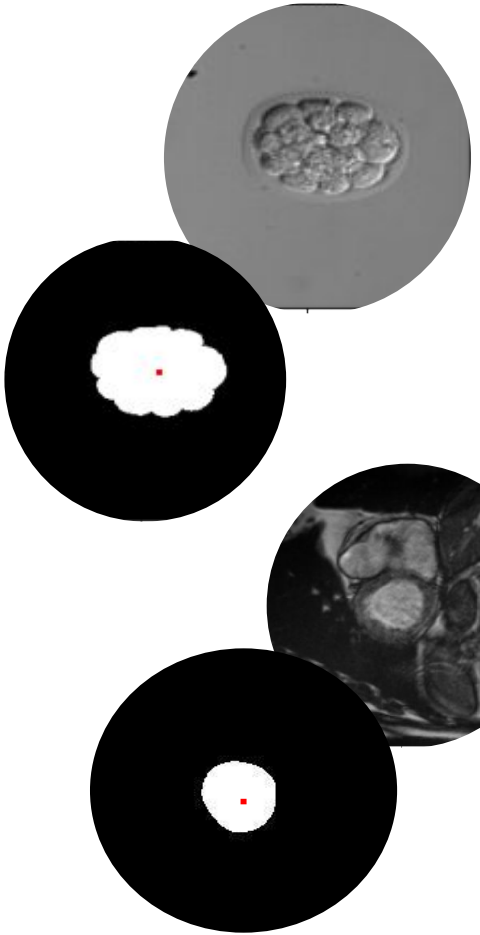


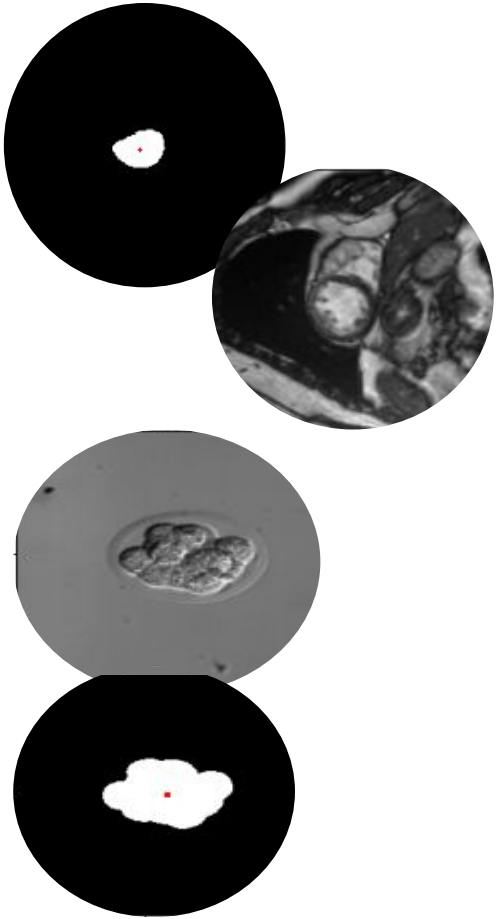


Training : 1516

Testing : 386

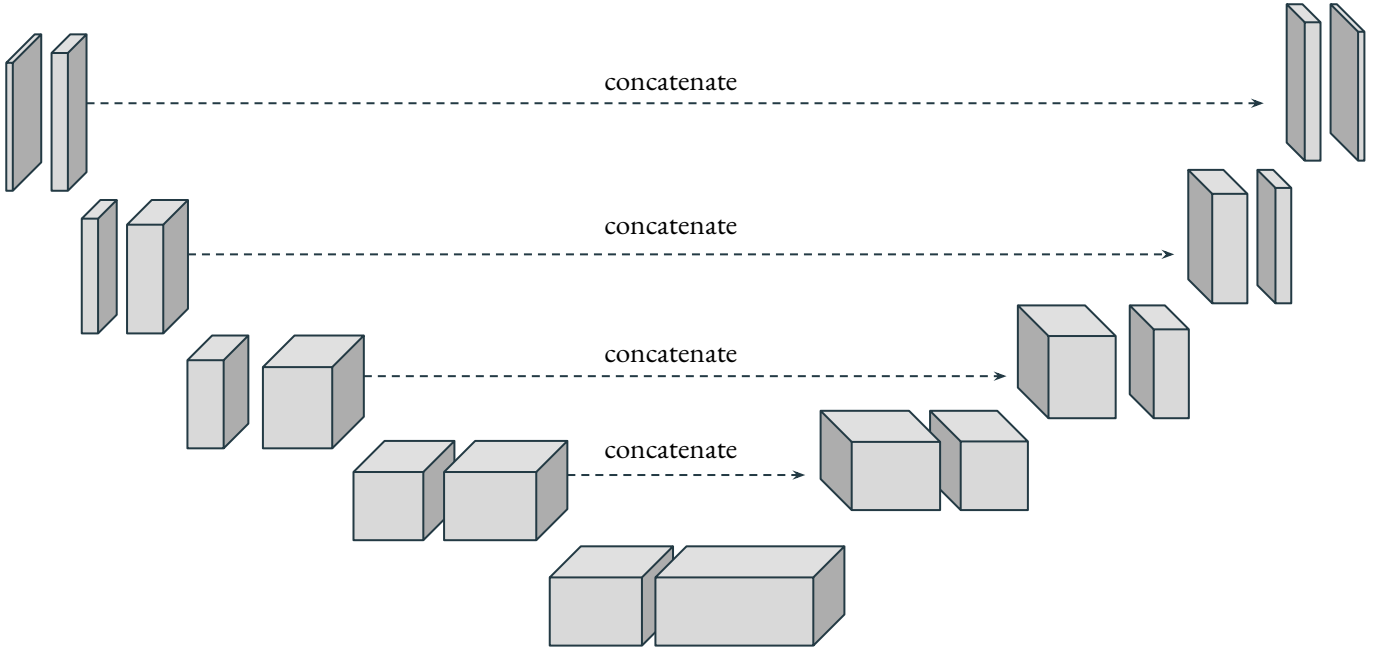
DYNAMIC PROGRAMMING



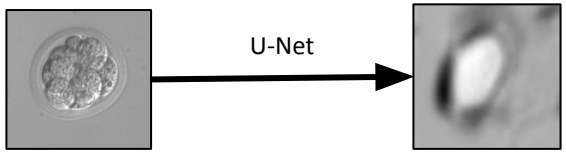


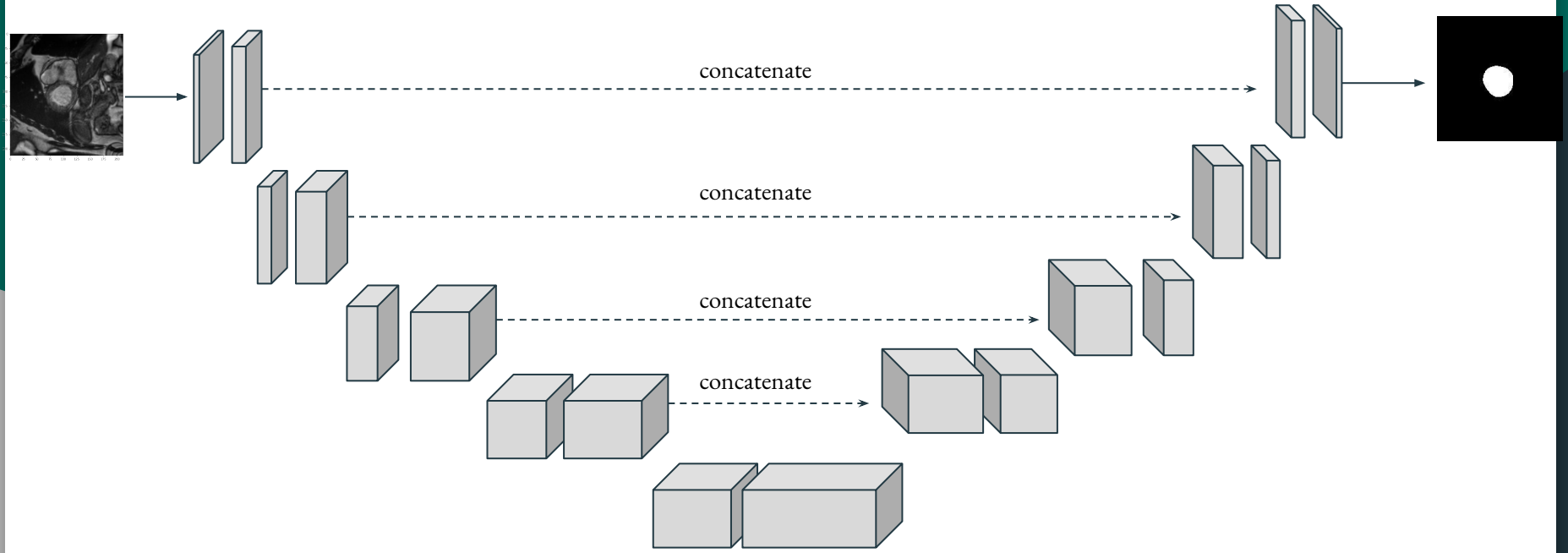
A SOLUTION

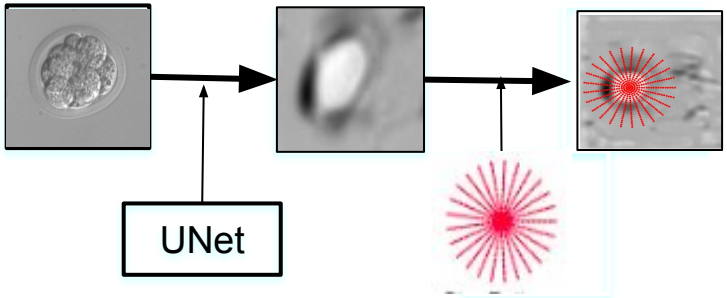
U-Net

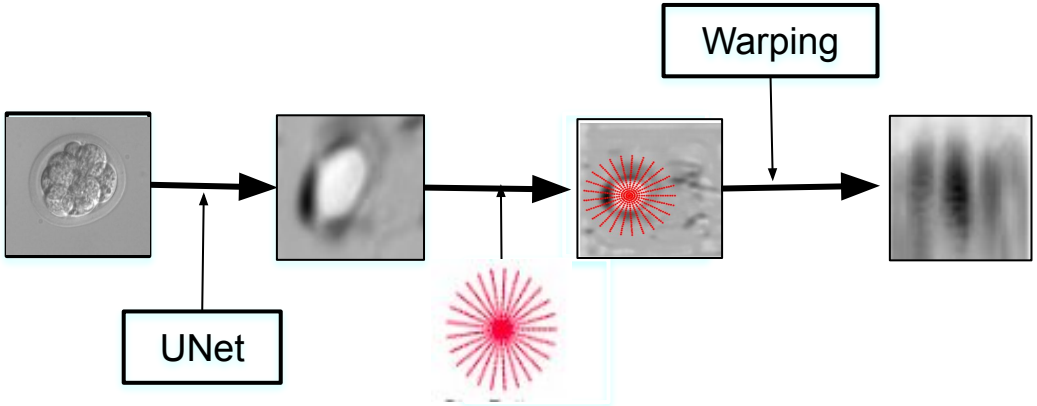


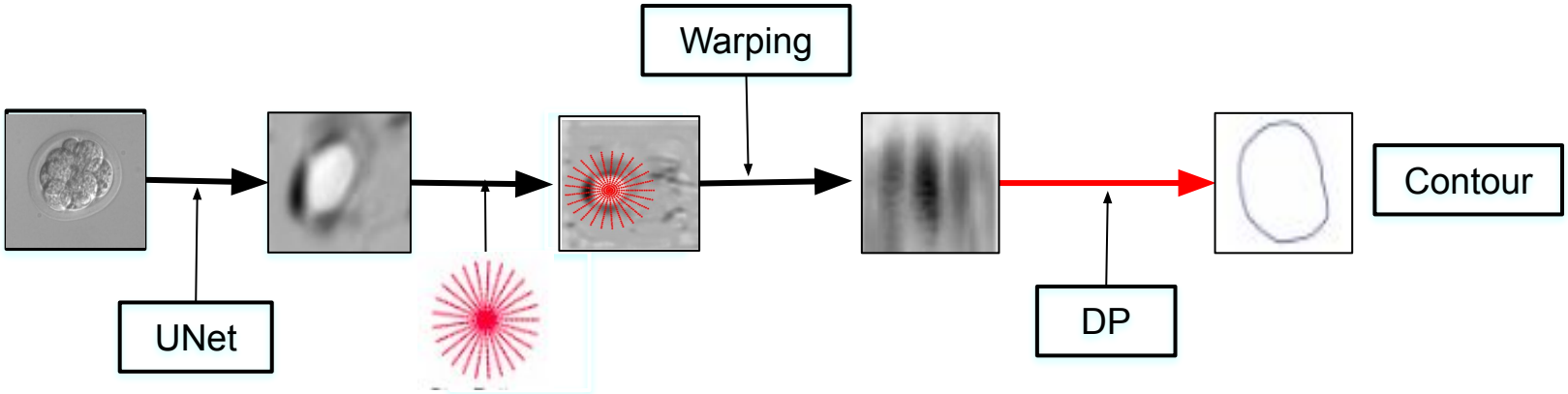
U-Net

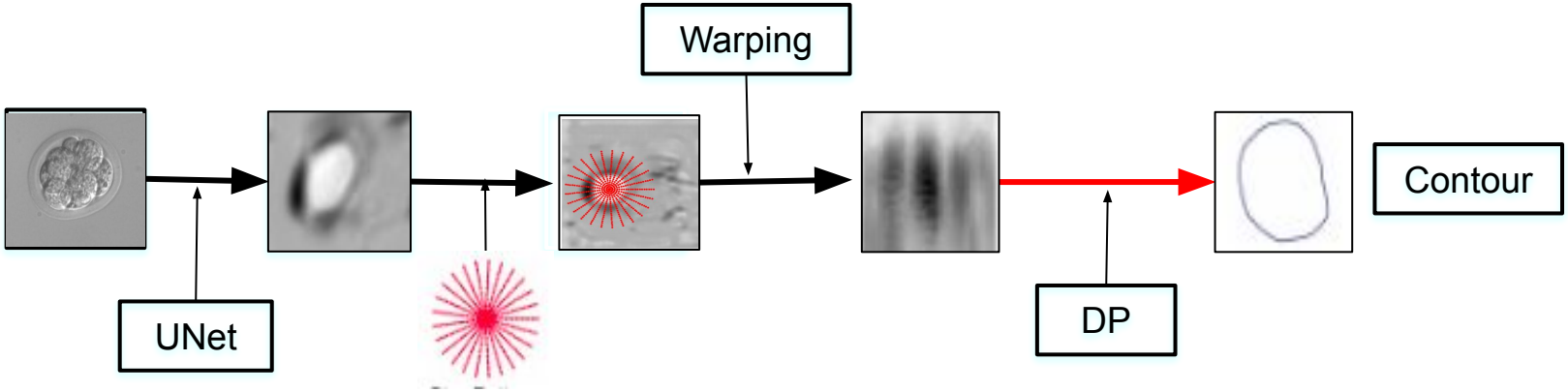


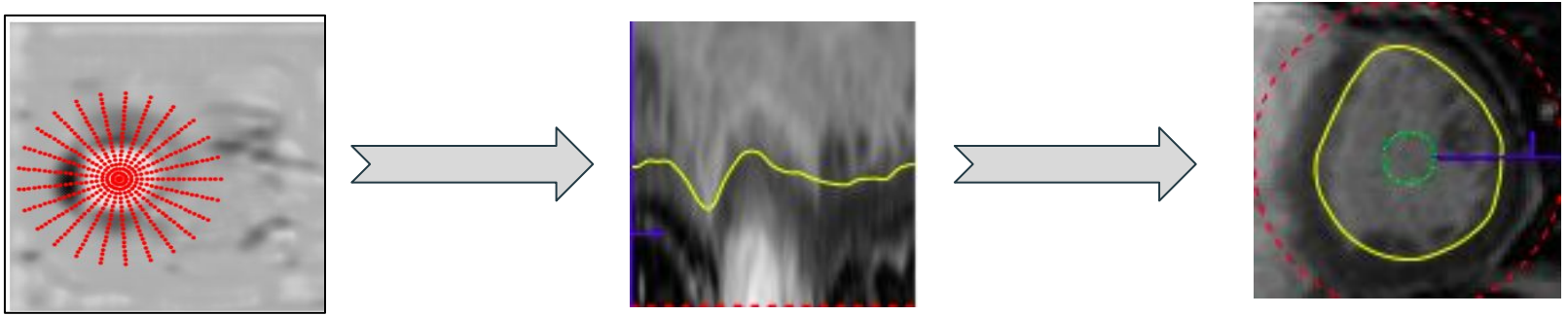



UNet


Warping
UNet


Warping
UNet
DP
Contour

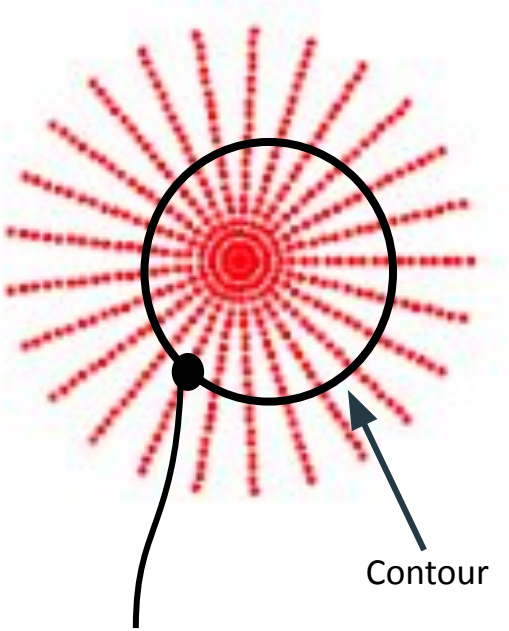

Warping
UNet
DP
Contour



Dynamic Programming

No. of radial lines : N
No. of candidate points on each line : M

Dynamic Programming



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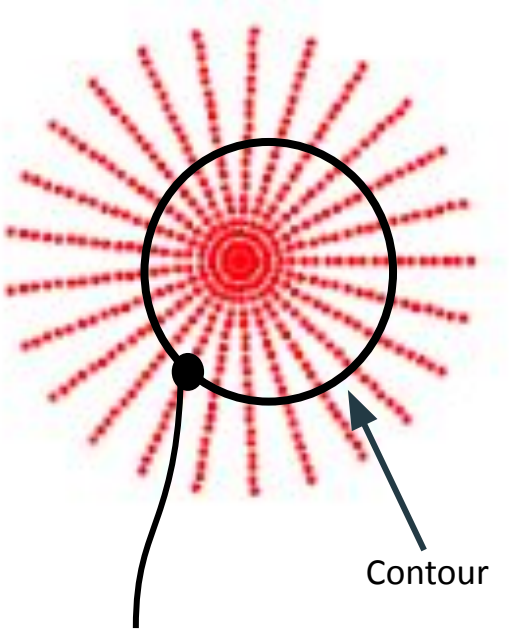
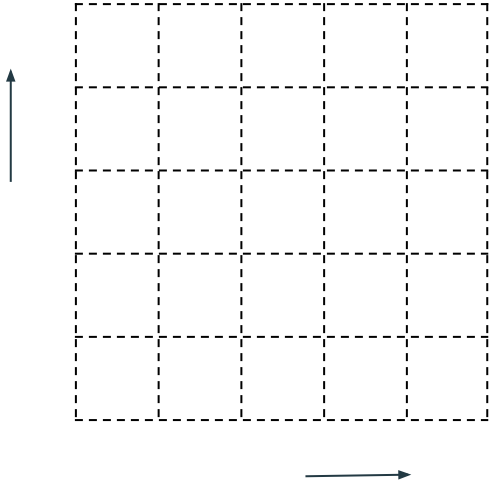
Dynamic Programming

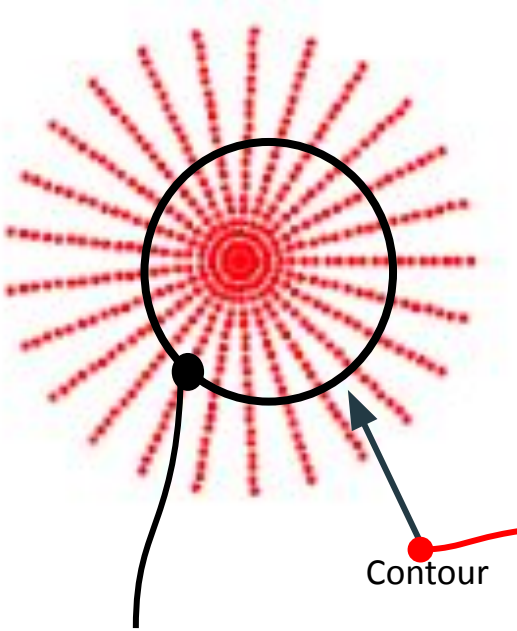


No. of radial lines : N
No. of candidate points on each line : M

g(n,i) : value of warped map on the i-th point on the n-th radial line.



Dynamic Programming



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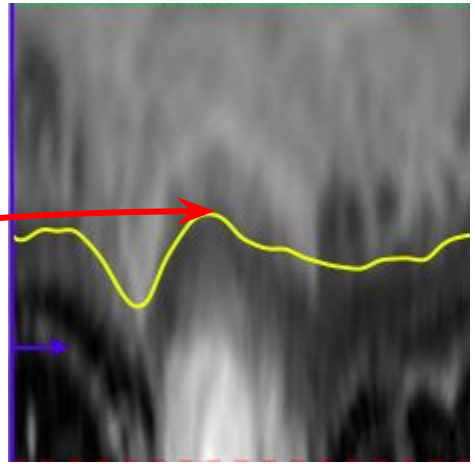
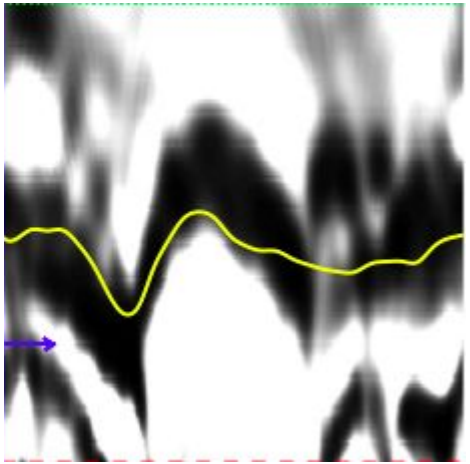
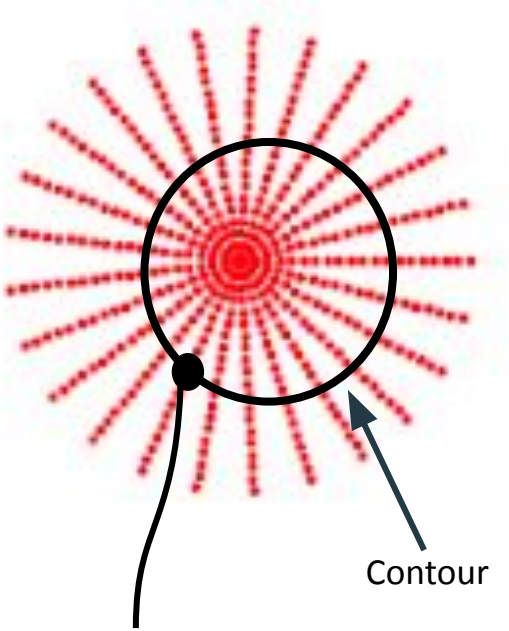
dg(n, i) = g(n, i) - g(n, i-1) , directional derivative on g





Dynamic Programming

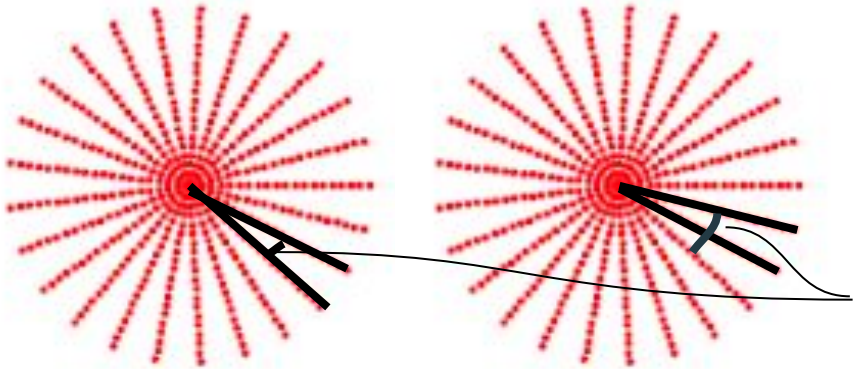


dg(n, i) = g(n, i) - g(n, i-1) , directional derivative on g

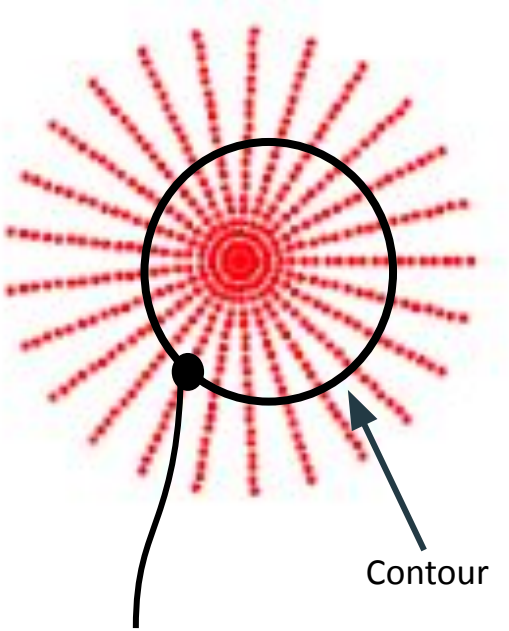
$$E(n,i,j) = \begin{cases} dg(n,i) + dg(n \oplus 1, j), \text{if } |i-j| \le \delta \\ \infty, \text{ otherwise,} \end{cases}$$

Our cost function:

$$\min_{v_1,\ldots,v_N} E(N, v_N, v_1) + \sum_{n=1}^{N-1} E(n, v_n, v_{n+1})$$



Dynamic Programming



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Our cost function:

$$\min_{v_1,\ldots,v_N} E(N, v_N, v_1) + \sum_{n=1}^{N-1} E(n, v_n, v_{n+1})$$

Loss function:

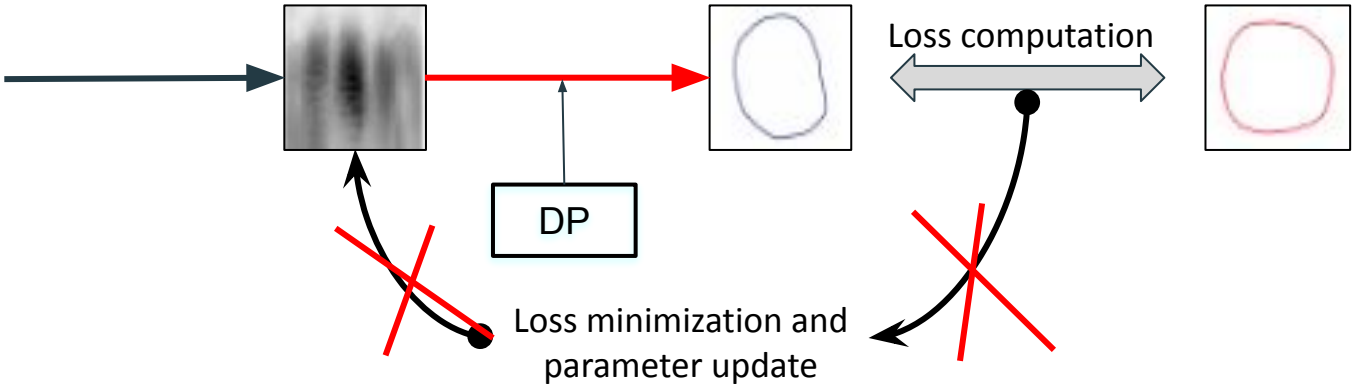
$$\min_{v_1,\ldots,v_N} E(N, v_N, v_1) + \sum_{n=1}^{N-1} E(n, v_n, v_{n+1})$$

Differentiable??

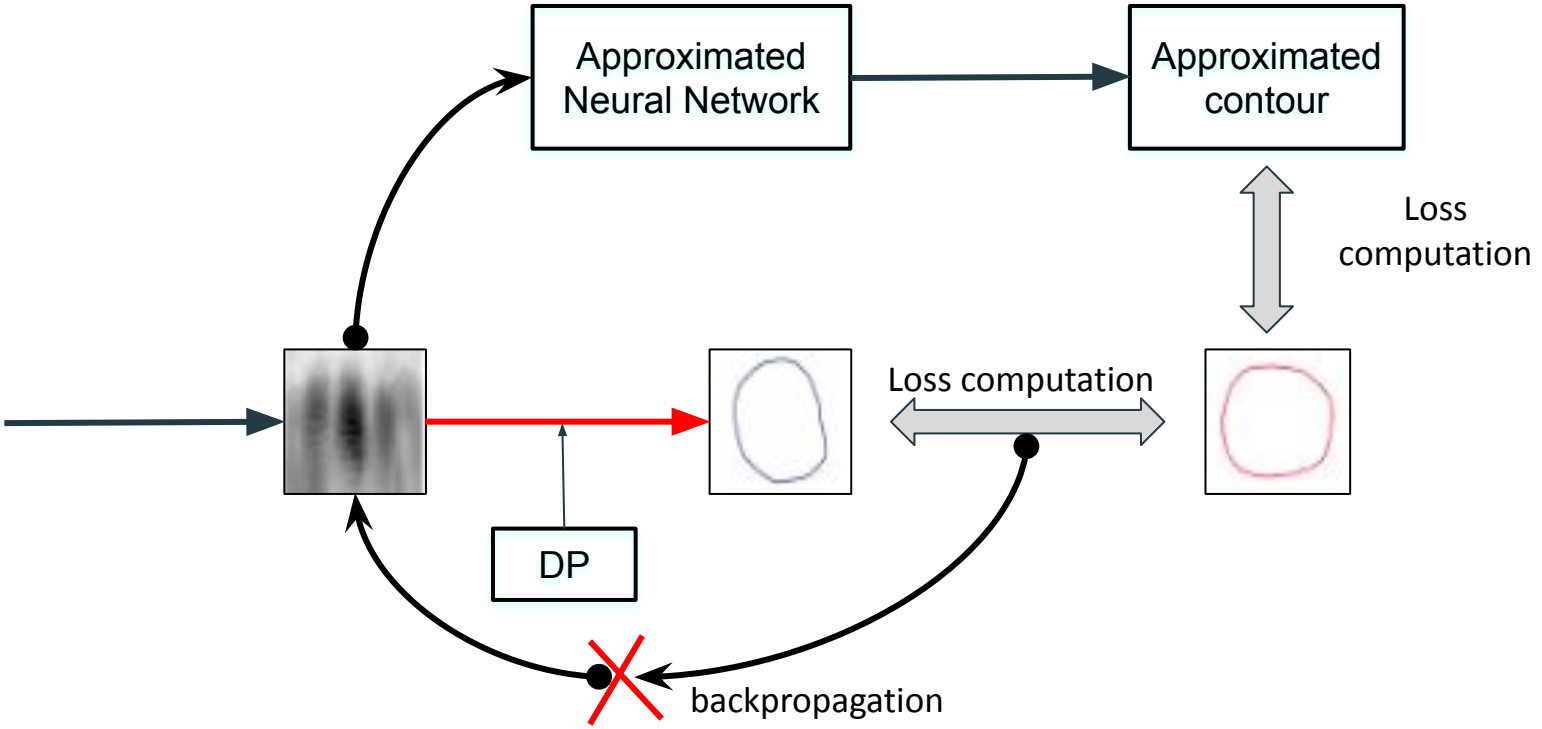
Loss function:

$$\min_{v_1,\ldots,v_N} E(N, v_N, v_1) + \sum_{n=1}^{N-1} E(n, v_n, v_{n+1})$$

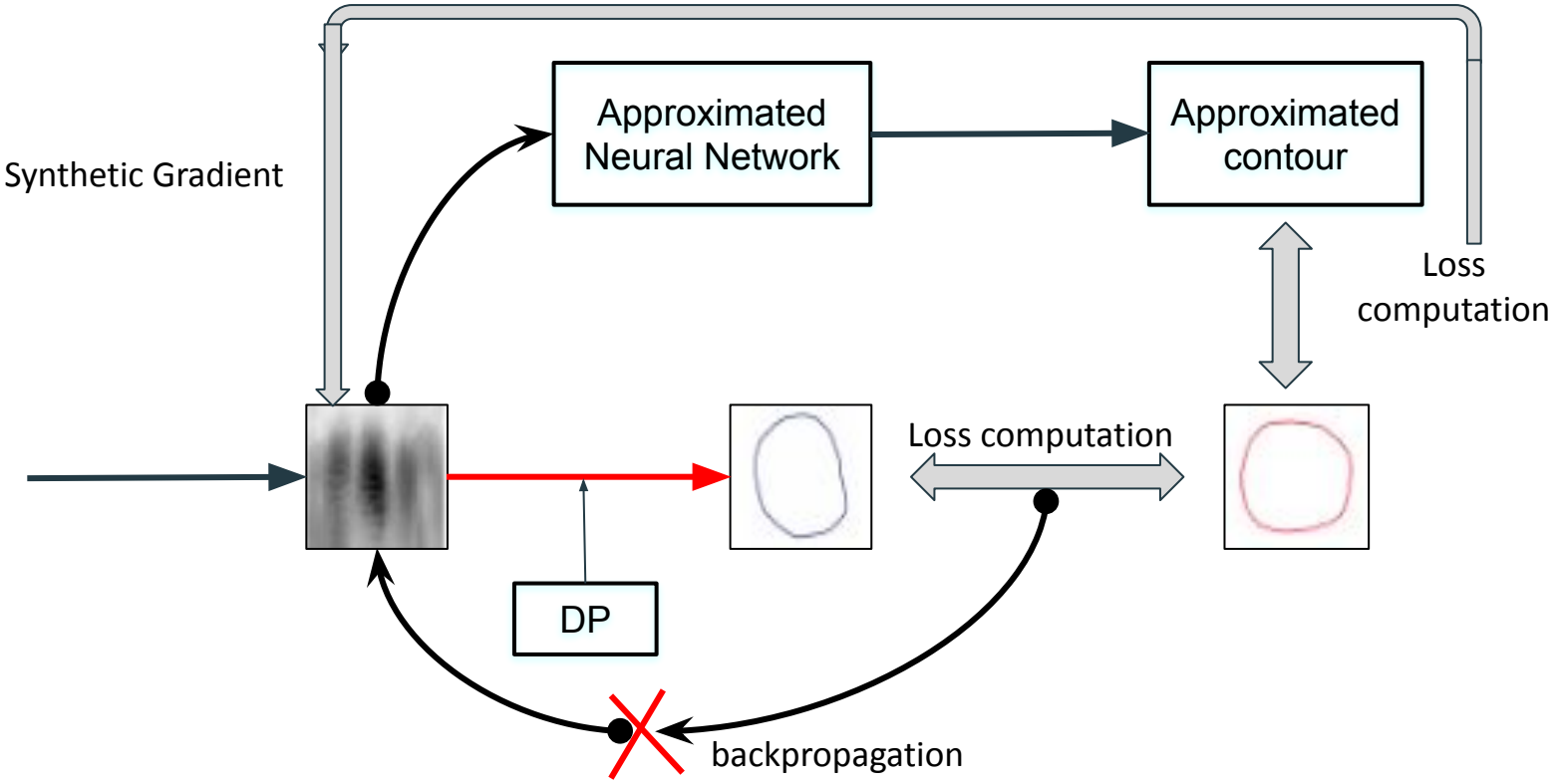
argmin !!

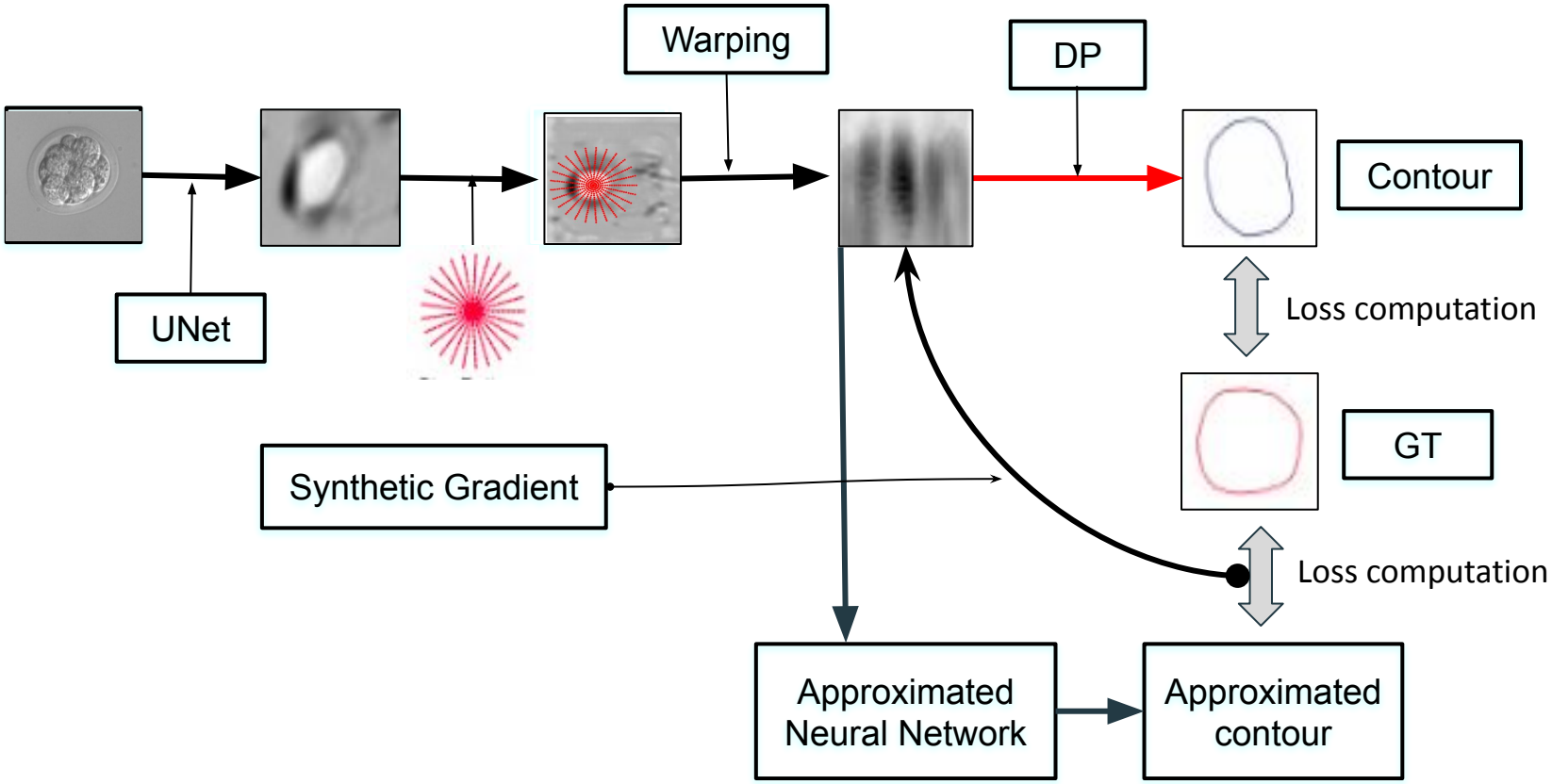


Approximated Neural Network

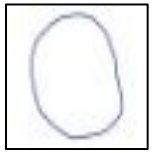


Approximated Neural Network



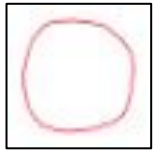

Warping
DP
Contour
UNet
Loss computation
GT
Synthetic Gradient
Loss computation
Approximated Neural Network
Approximated contour

Introduce the randomness



DP(g)

Exact loss



Ground Truth

Mimicked loss

Approximated contour

F(g)

For the DP module, the output is *DP(g)*

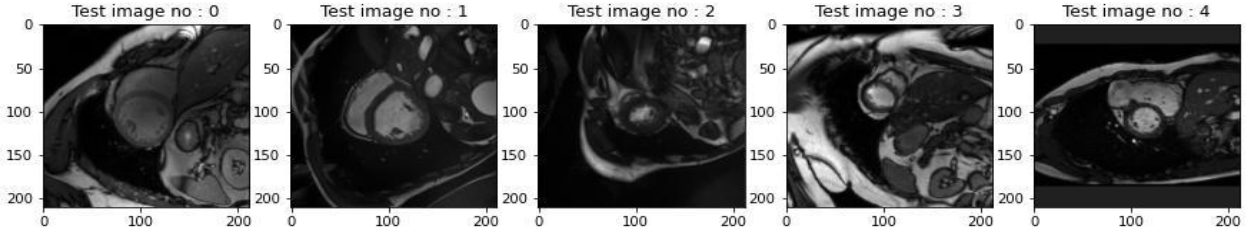
For the approximated module, the output is *F(g)*

Mimicked loss: *L(F(g), DP(g))*

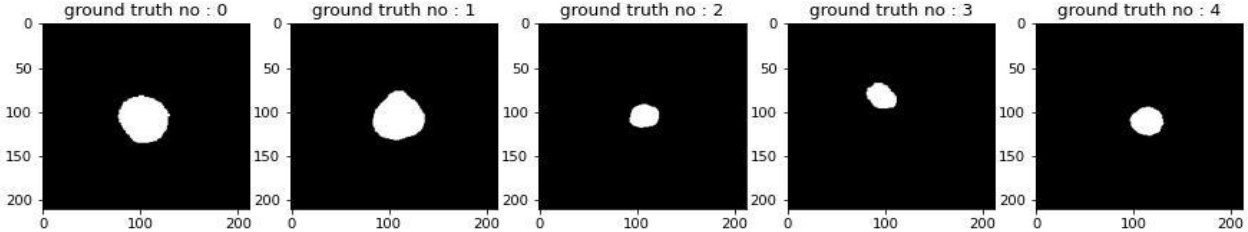
Randomized loss: $L(F(g + \sigma\varepsilon), DP(g + \sigma\varepsilon))$

RESULTS

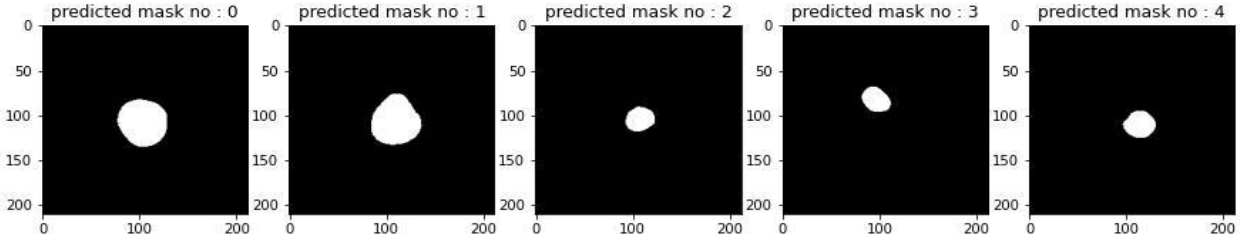
Images



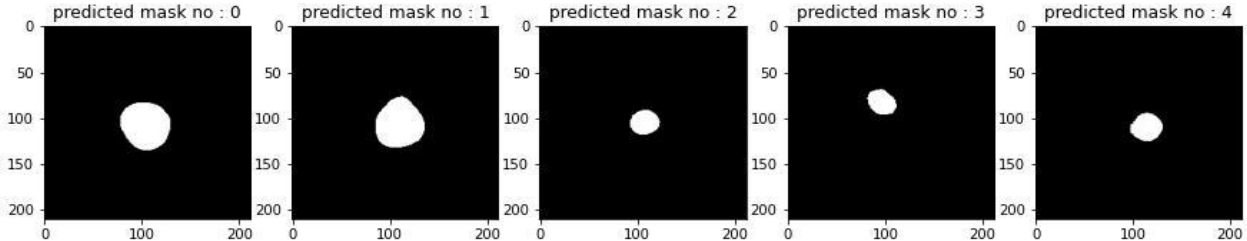
Ground Truth



U-Net



EDPCNN

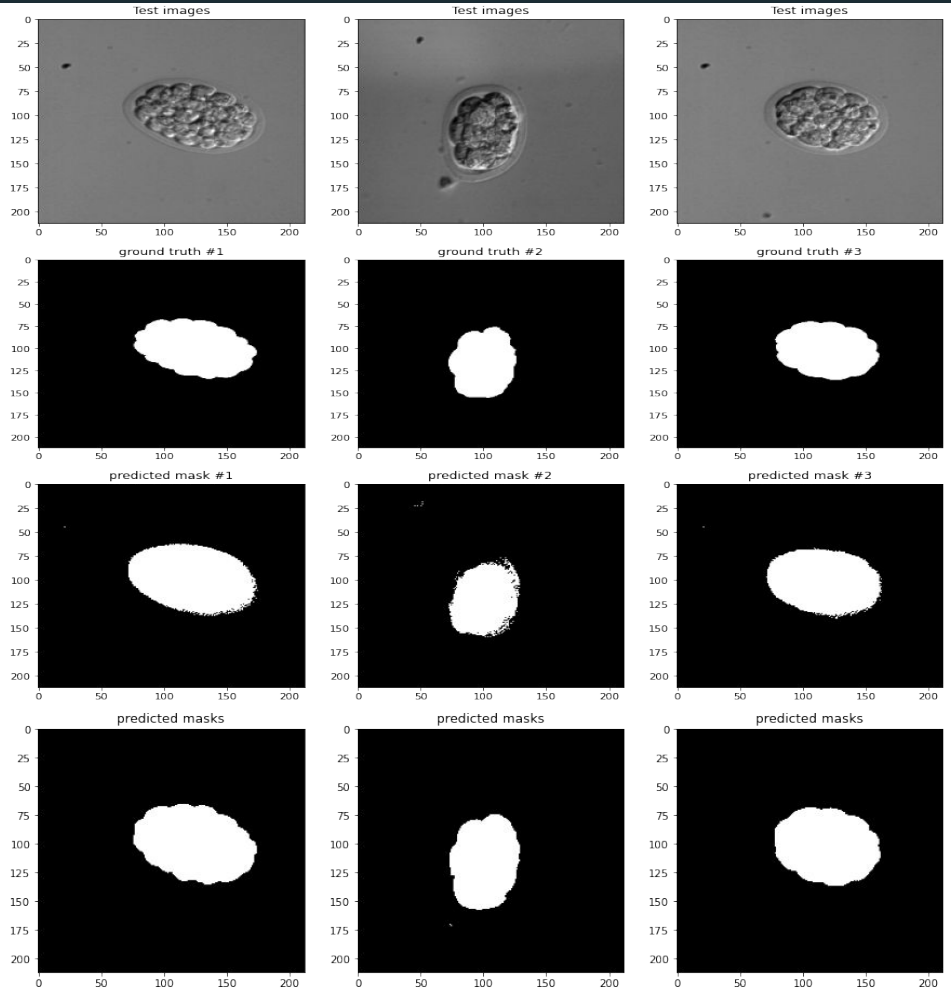


Images

Ground Truth

U-Net

EDPCNN



CONCLUSION

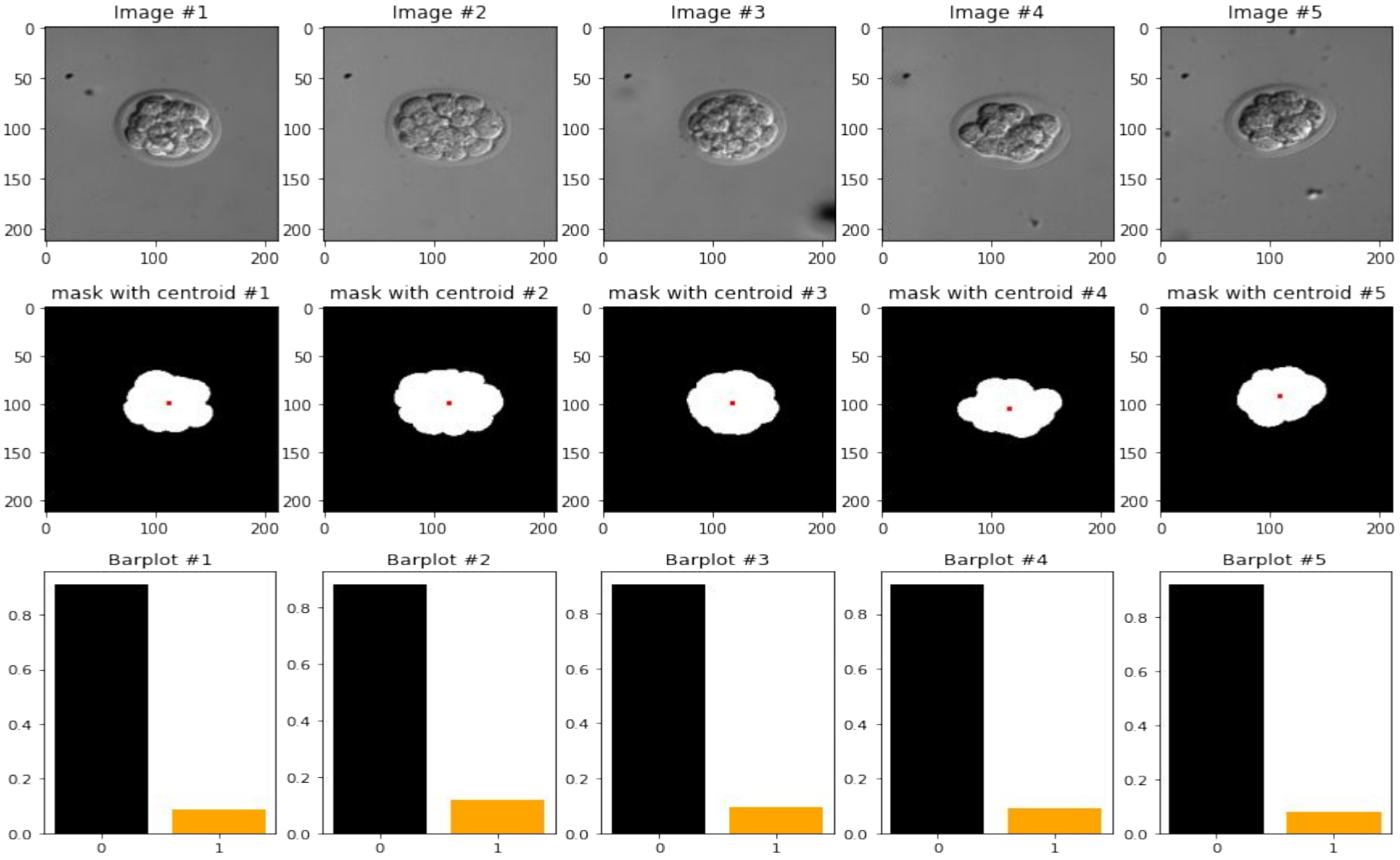


Image #1
Image #2
Image #3
Image #4
Image #5
mask with centroid #1
mask with centroid #2
mask with centroid #3
mask with centroid #4
mask with centroid #5
Barplot #1
Barplot #2
Barplot #3
Barplot #4
Barplot #5

Further Scope of Improvements

- ➔ Cell no. detection in embryo.
- ➔ Segment myocardium and right ventricle or multiple cells with automated placement of multiple star patterns.
- ➔ Disease prediction from heart masks.

THANK YOU