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~~1a γ_λ is not increasing, as it will only remove pixels and never add them~~

1a γ_λ is increasing, because $X \subseteq Y \Rightarrow \gamma_\lambda(X) \subseteq \gamma_\lambda(Y)$ holds. Namely, if a connected component is in $\gamma_\lambda(X)$, then apparently it was in X also. As $X \subseteq Y$, every pixel in this connected component is also part of a conn. component in Y that is at least as big, and is therefore also in $\gamma_\lambda(Y)$.

0.5

b γ_λ is anti-extensive, as $\gamma_\lambda(X) \subseteq X$. This is because γ_λ can only remove pixels, not add them.

0.5

c γ_λ is not an opening, because then we could find a structuring element A such that $\gamma_\lambda(X) = X \circ A$. Suppose $X = A$, then $\gamma_\lambda(A) = A \circ A = A$, so λ is at least the area of the smallest connected component of A. Now move one pixel in this smallest connected component to another location, while keeping it attached to the component; call the result B. Obviously $\gamma_\lambda(B) = B \circ A = \emptyset$. But this cannot be, since the ~~size~~ area of the connected component has remained the same, so it should still pass the filter.

1

correct given this def of an opening
a wider definition is that it is an idempotent, anti-extensive and increasing operator

d φ_λ is not increasing. Call the open 3x3 square A ($A = $ ▣) and the closed one B ($B = $ ■), then $A \subseteq B$. Take $\lambda = 17$. φ_λ will remove B as it has a perimeter of 16 pixels, but leaves A with a perimeter of 17 pixels in place; so $\varphi_\lambda(B) = \emptyset$ whereas $\varphi_\lambda(A) = A$, so $\varphi_\lambda(A) \not\subseteq \varphi_\lambda(B)$.

0.5

2.5

2a c: the snake expands to the image edges as it starts outside the bacterium

d: the snake expands to enclose only the left half as it will not pass the boundary

e: the snake will expand to the image edges at the top right, while still only enclosing the right half of the bacterium

0.75

the bacterium

0.5 d: the snake will contract to a point as there is nothing for it to enclose

e: the snake will contract to contain only the right part of the bacterium, as it will never grow to include the left part

c The smoothness must be relaxed near the dimples

0.25 in the center in order for the snake to fill them.

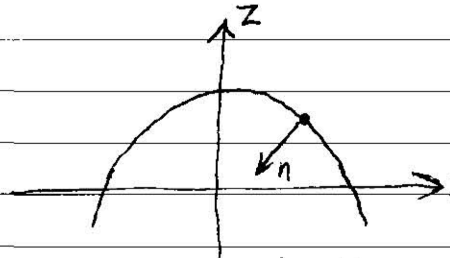
2.0

3a $\frac{\partial z}{\partial x} = -2x, \quad \frac{\partial z}{\partial y} = -2y$

$n = \left(\frac{\partial z}{\partial x}, \frac{\partial z}{\partial y}, -1\right) = (-2x, -2y, -1)$

$s = (a, b, c)$

1.5 $E(x, y) = \frac{n \cdot s}{\|n\| \, \|s\|} = \frac{-2ax - 2by - c}{\sqrt{4x^2 + 4y^2 + 1}}$



I do not see ~~where~~ how the minus signs and the square root should disappear... -> correct Fout in opgave excuses

b $s = (1, 0, 0) \Rightarrow a = 1, \; b = 0, \; c = 0.$

$E(x, y) = \frac{2x}{4(x^2+y^2)+1} < 0$ for $x < 0$.

1.0 In these cases, the surface is lighted from the back as the dot product is negative so the light makes an angle of over 90° with the front surface normal.

2.5

4a Say a is the unit direction vector of AB and DC, and b is the unit direction vector of AD and BC.

Then $a \cdot b = \cos\alpha$. We also have:

$(a_1, a_2, a_3) = \frac{1}{\sqrt{u_\infty^2 + v_\infty^2 + f^2}} (u_\infty, v_\infty, f) = \frac{1}{\sqrt{f^2+5}} (2, 1, f)$

$(b_1, b_2, b_3) = \frac{1}{\sqrt{u_\infty'^2 + v_\infty'^2 + f^2}} (u'_\infty, v'_\infty, f) = \frac{1}{\sqrt{f^2+5}} (2, -1, f)$

So $\left(\frac{1}{\sqrt{f^2+5}}(2, 1, f)\right) \cdot \left(\frac{1}{\sqrt{f^2+5}}(2, -1, f)\right) = \cos\alpha$:

$\cos\alpha = \frac{1}{f^2+5}(4 - 1 + f^2) = \frac{f^2+3}{f^2+5}$

$f^2 + 3 = \cos\alpha \, (f^2 + 5) = \cos\alpha \, f^2 + 5\cos\alpha$

$(1 - \cos\alpha) f^2 = 5\cos\alpha - 3$

$f = \sqrt{\frac{5\cos\alpha - 3}{1 - \cos\alpha}}$

b This would require $f = \sqrt{\frac{-3}{1}} = \sqrt{-3} \notin \mathbb{R}$, which is clearly impossible.

2.0