4 Computer Vision (JGD)

(*a*) Consider an object's surface reflectance map $\phi(i, e, g)$ specifying the amount of incident light reflected towards a camera from each point on the surface, where the angle of the illuminant (a point source) relative to the local surface normal N is i, the angle relative to N of a ray of light re-emitted from the surface is e, and the angle between the emitted ray and the illuminant is g.

(*i*) For what kind of surface is the reflectance map simply $\phi(i, e, g) = \cos(i)$? Name this type of surface and describe its key properties. [4 marks]

(*ii*) For what kind of surface does the reflectance map simplify to $\phi(i, e, g) = 1$ if $i = e$ and both i and e are coplanar with the surface normal N, and $\phi(i, e, g) = 0$ otherwise? Name this type of surface and describe its key properties. [4 marks]

(*iii*) For what kind of surface does the reflectance map depend only on the ratio of the cosines of the angles of incidence and emission, $\cos(i)/\cos(e)$, but not upon their relative angle g nor upon the surface normal N? Give an example of such an object, and explain the consequence of this special reflectance map for the object's appearance. [4 marks]

(*b*) The binary pixel array on the left below was convolved with what operator $\boxed{?}$ to produce the result on the right? Specify the operator by numbers within an array, and identify what task this convolution accomplishes in computer vision.

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	**1**	**1**	**1**	**1**	0	0	0
0	0	0	**1**	**1**	**1**	**1**	0	0	0
0	0	0	**1**	**1**	**1**	**1**	0	0	0
0	0	0	**1**	**1**	**1**	**1**	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

$* \ \boxed{?} \ \Rightarrow$

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	**-1**	**1**	0	0	**1**	**-1**	0
0	**-1**	**1**	0	0	**1**	**-1**	0
0	**-1**	**1**	0	0	**1**	**-1**	0
0	**-1**	**1**	0	0	**1**	**-1**	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

[4 marks]

(*c*) When visually inferring a 3D representation of a face, it is useful to extract separately both a shape model, and a texture model. Explain the purposes of these steps, their use in morphable models for pose-invariant face recognition, and how the shape and texture models are extracted and later re-combined.

[4 marks]