# Texture Mapping: 2D Texturing



## Texture Mapping

Visual complexity on demand

Vary display properties over object

Visible pixel maps to location on object

Location on object
- used to lookup display attributes

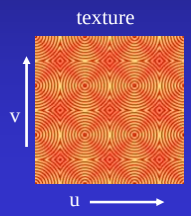
Or
- as function parameters to generate attributes



## 2D Texture Mapping

Usually a 2D rectangular image or function

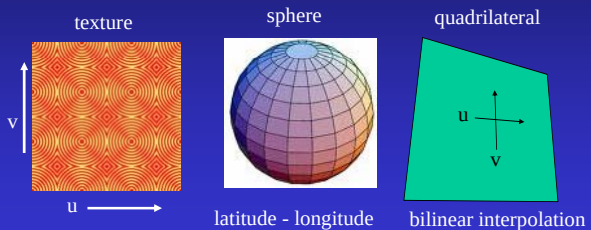
Parameterize using (u,v) texture coordinates



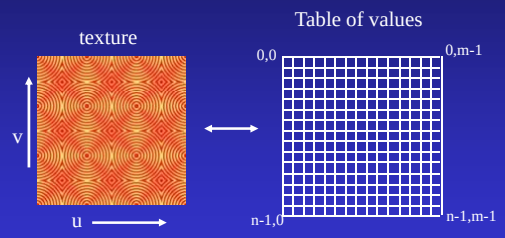



## 2D Texture Mapping

Need to parameterize surface similar to texture



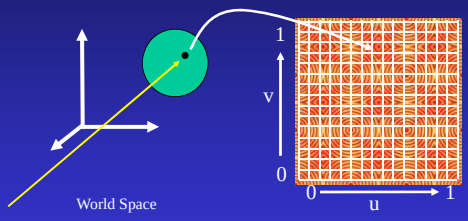
## Texture as table of values




Values at grid intersections



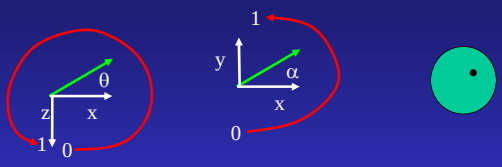
## For sphere
## Texture Map Coordinates




Map (x,yz) to u,v space to table values



## For sphere
## map sphere surface to (u,v)



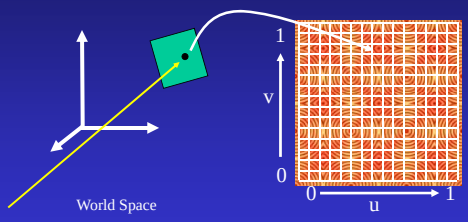

$$s = \frac{\tan^{-1}(z/x)}{\pi/2}$$
$$if\,(x>0)\{\ u = (1+s)/4\}$$
$$else\{u = 1/2 + (1-s)/4\}$$

$$t = \frac{\tan^{-1}(\frac{y}{x})}{\pi/2}$$
$$v = \frac{t+1}{2}$$

BUT -
Has a seam
& distorts

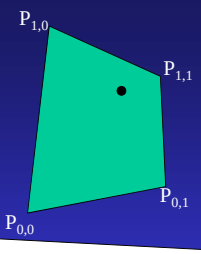


## For quadrilateral
## Texture Map Coordinates




Map (x,yz) to u,v space to table values

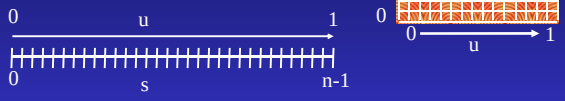
## World space point to u,v space




$$P_{u,0} = P_{0,0} + u(P_{1,0} - P_{0,0})$$
$$P_{u,1} = P_{0,1} + u(P_{1,1} - P_{0,1})$$
$$P_{u,v} = P_{u,0} + v(P_{u,1} - P_{u,0})$$
$$P_{u,v} = P_{0,0} + u(P_{1,0} - P_{0,0}) + v(P_{0,1} + u(P_{1,1} - P_{0,1}) - P_{0,0} + u(P_{1,0} - P_{0,0}))$$
$$P_{u,v} = P_{0,0} + u(P_{1,0} - P_{0,0}) + v(P_{0,1} - P_{0,0}) + uv(P_{1,1} - P_{0,1} + P_{1,0} - P_{0,0})$$
$$u = \frac{P_{u,v} - P_{0,0} - v(P_{0,1} - P_{0,0})}{(P_{1,0} - P_{0,0}) + v(P_{1,1} - P_{0,1} + P_{1,0} - P_{0,0})}$$



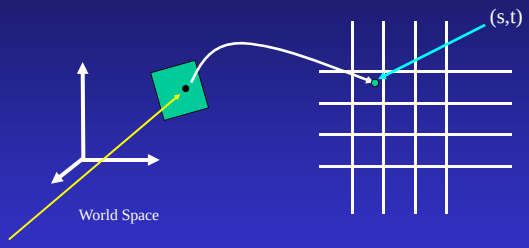
## u,v space to table indice space




$$s = u(n-1)$$
$$t = m - 1 - v(m-1)$$



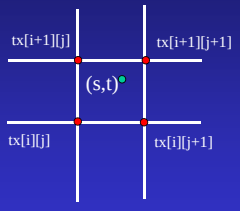
## A closer look




Values only at the intesections
What value to use at non-intersection point?



## Closer still

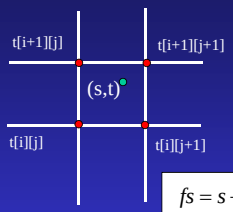



Use closest value?

$$i = \lfloor s + 0.5 \rfloor$$
$$j = \lfloor t + 0.5 \rfloor$$

$$txst = tx[i][j]$$

## Closer still



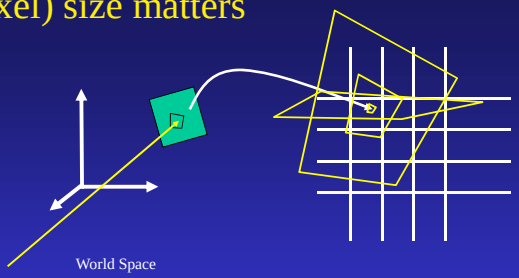

Interpolate 4 closest?

$$i = \lfloor s \rfloor$$
$$j = \lfloor t \rfloor$$

$$fs = s - \lfloor s \rfloor$$
$$ft = t - \lfloor t \rfloor$$
$$ts1 = tx[i][j] + fs(tx[i+1][j] - tx[i][j])$$
$$ts2 = tx[i][j+1] + fs(tx[i+1][j+1] - tx[i][j+1])$$
$$txst = ts1 + ft(ts2 - ts1)$$



## (Pixel) size matters

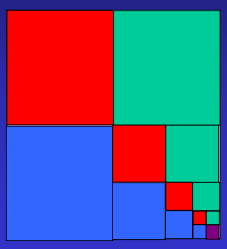



Can't just use pixel center and expect good results in all cases - need to consider how entire pixel maps into texture space



## One solution: Mip-mapping

Pre-filter texture, reducing resolution
(increase size of grid relative to pixel size)



Successive table of values (r,g,b) at reduced resolution

Down to single pixel

Index into highest resolution one in which bilinear interpolation makes sense