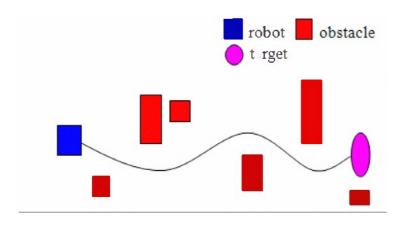
## Path following for mobile robots Guiding Vector Fields (GVF)

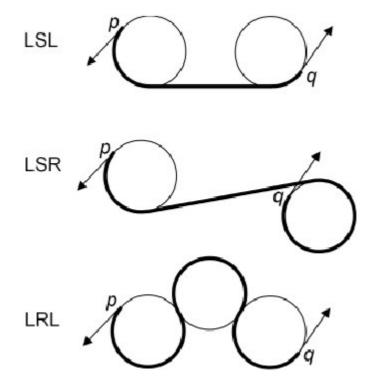
Given a desired path, how does a robot follow it?





### Following straight lines and circles

Dubin's path consists of a sequence of lines and circles



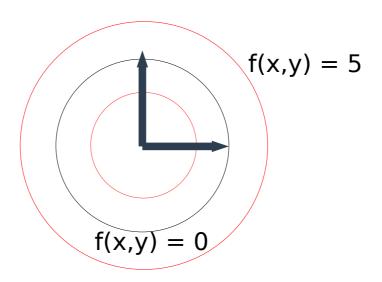
### Implicit equations of the path

Circle 
$$\rightarrow$$
 f(x,y) := (x-xc)<sup>2</sup> + (y-yc)<sup>2</sup> + r<sup>2</sup> = 0

Straight line 
$$\rightarrow$$
 f(x,y) := ax + by + c = 0

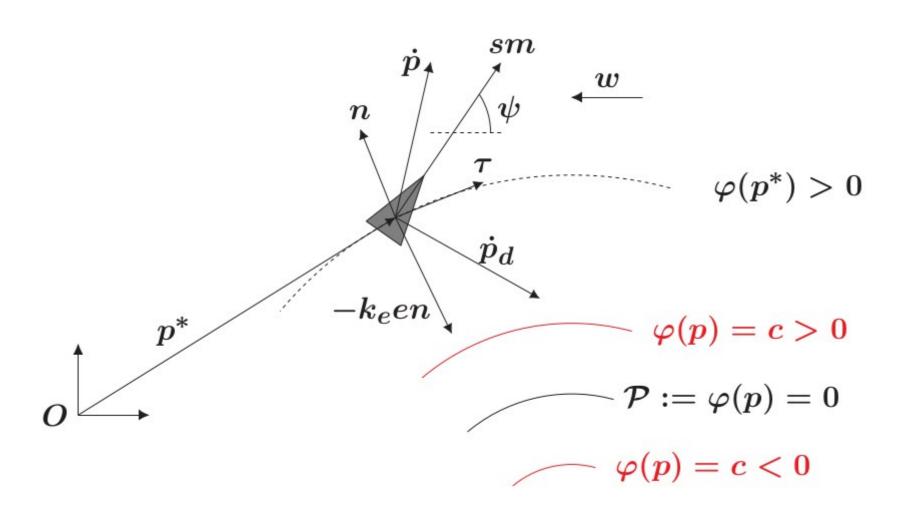
#### **Level sets**

$$x^2 + y^2 - r^2 = 5$$
 Outer  
 $x^2 + y^2 - r^2 = 0$  Target trajectory  
 $x^2 + y^2 - r^2 = -5$  Inner



f(x,y) can be used as an error signal!

# How to follow the desired trajectory? We need the normal and tangent vectors



### We need the Jacobian of the path

Circle 
$$\rightarrow$$
 f(x,y) := (x-xc)<sup>2</sup> + (y-yc)<sup>2</sup> + r<sup>2</sup> = 0

Straight line 
$$\rightarrow$$
 f(x,y) := ax + by + c = 0

The Jacobian tells us in which direction the level set grows! (normal to the path)

Jacobian of the circle

Jac = 2[(x-xc) (y-yc)] is the normal vector to the circle

Jacobian of the straight line

Jac = [a b] is the normal vector to the line

### We need the tangent to the path

It is just the 90 degrees rotation of the Jacobian

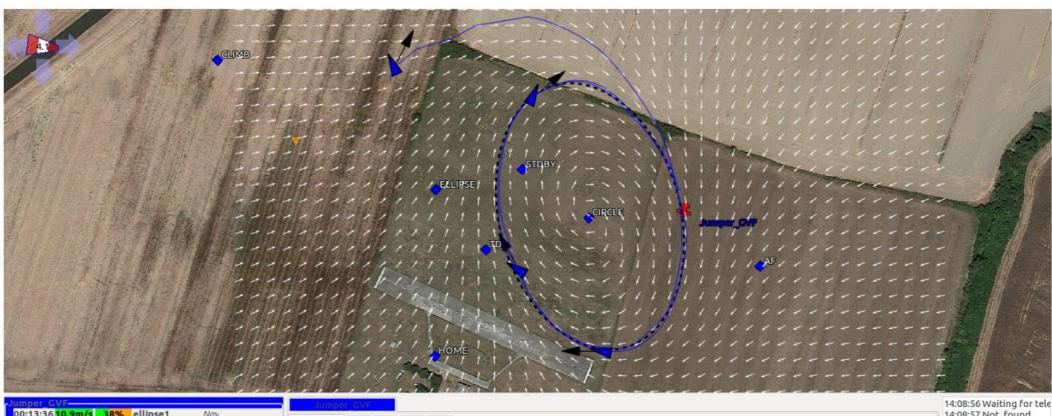
Tangent = Rot(90) Jac

## The direction to follow is the combination of the normal and tangent

Control action or direction to follow e:=f(x,y) (error signal)

Direction to follow = tangent - e\*normal

### **Example with an ellipse**





Flight Plan GPS PFD Link Misc ▶ block Holding point ▶ block Takeoff ▶ block Standby ▶ block circle ▶ block ▶ block ellipse2 ▶ block Land Right AF-TD ▶ block Land Left AF-TD

14:08:56 Waiting for tele 14:08:57 Not\_found 14:08:57 Jumper\_GVF, A 14:08:57 Jumper\_GVF, Ii 14:08:57 Jumper\_GVF, Ii 14:08:57 Jumper\_GVF, Ii 14:18:02 Jumper\_GVF, Ii 14:18:07 Jumper\_GVF, Ii 14:20:08 Jumper\_GVF, Ii 14:20:14 Jumper\_GVF, Ii 14:20:41 Jumper\_GVF, Ii 14:20:47 Jumper\_GVF, Ii