Tuning Costmaps for Social Navigation

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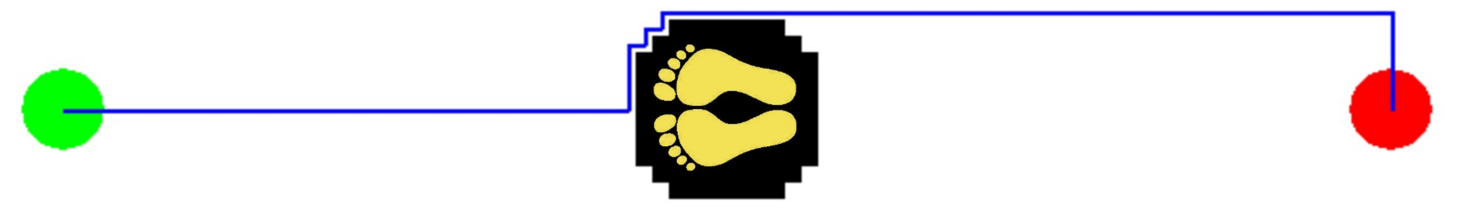
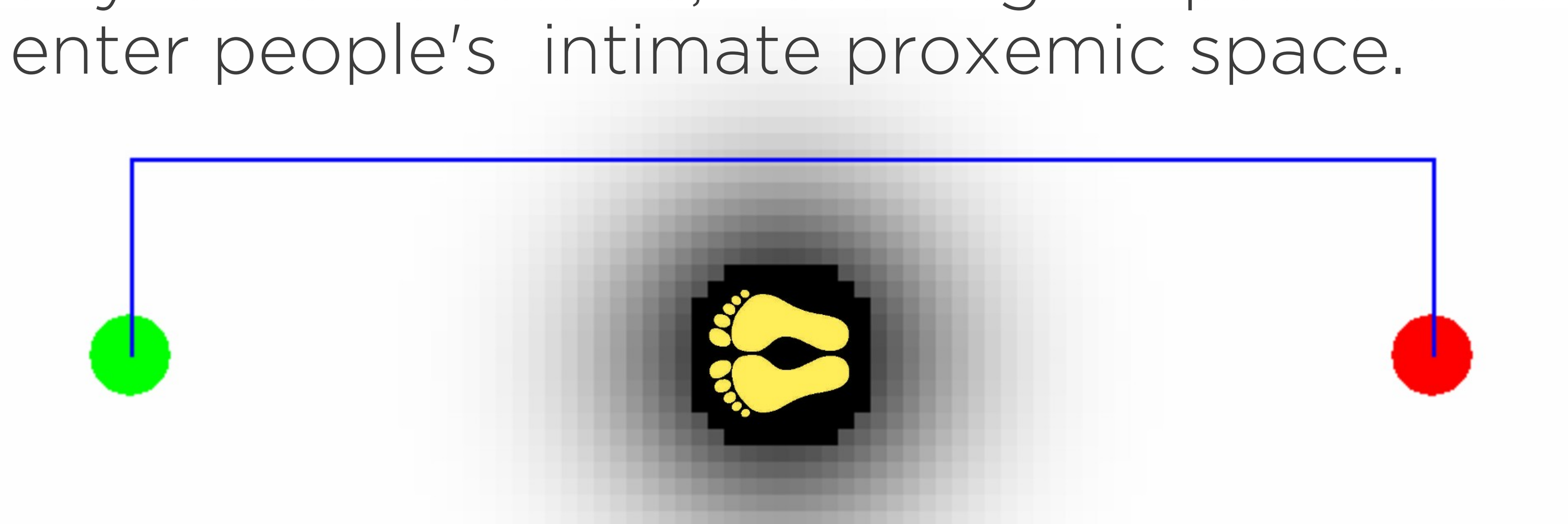
Paper #096

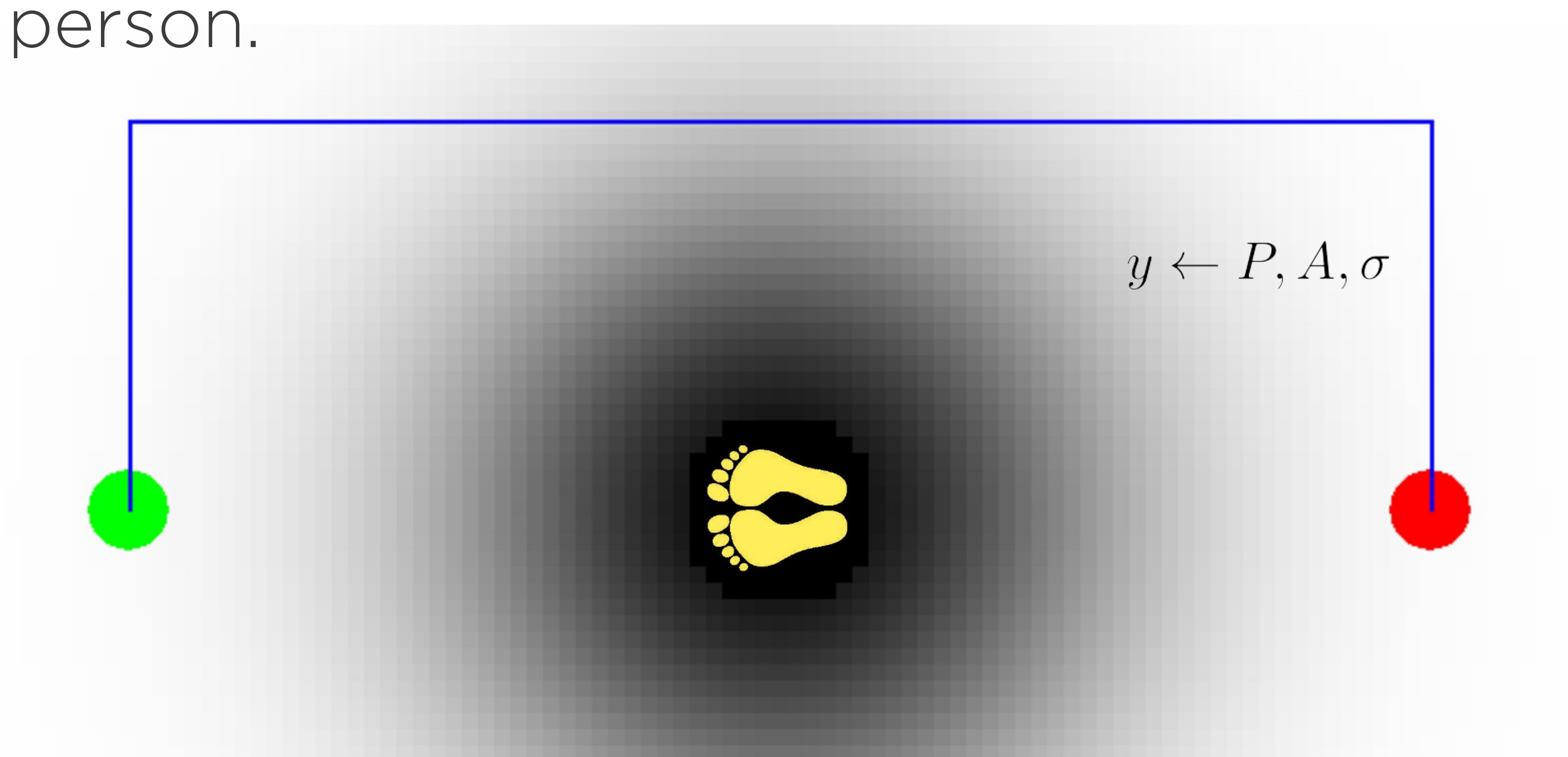
Problem Formulation



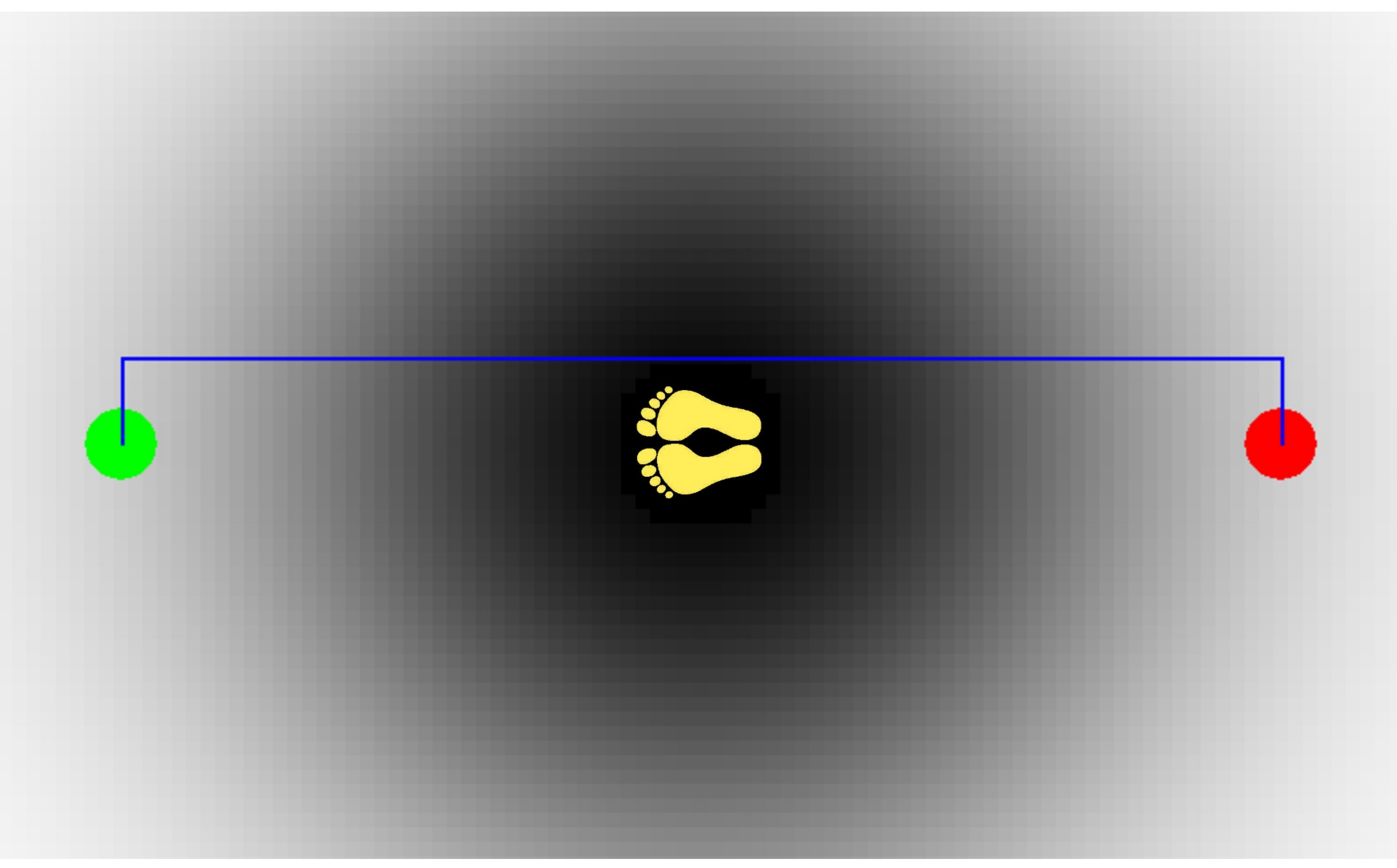
Most navigation algorithms treat people like any other obstacle, resulting in paths that enter people's intimate proxemic space.



Adding costs with a Gaussian distribution, as in (Sisbot et al. 2007) (Kirby, 2009) (Svenstrup, 2010) (Scandolo and Fraichard, 2011) moves the paths further from the person.



Precisely how far away from the person (y) depends on two variables from the Gaussian (amplitude A and variance σ) and one from the planning algorithm (path constant P). The relationship is complex, and has in the past only been explored by guesswork.



While increasing the Gaussian parameters and decreasing P generally lead to increased path distances, changes past a certain limit lead to the minimal path, back in the person's personal space.

Analytical Solution

$$\arg\min_{\text{path}} \sum_{p_i \in \text{path}} \left(P + A \exp\left(- \frac{|p_i|}{2\sigma^2} \right) \right)$$

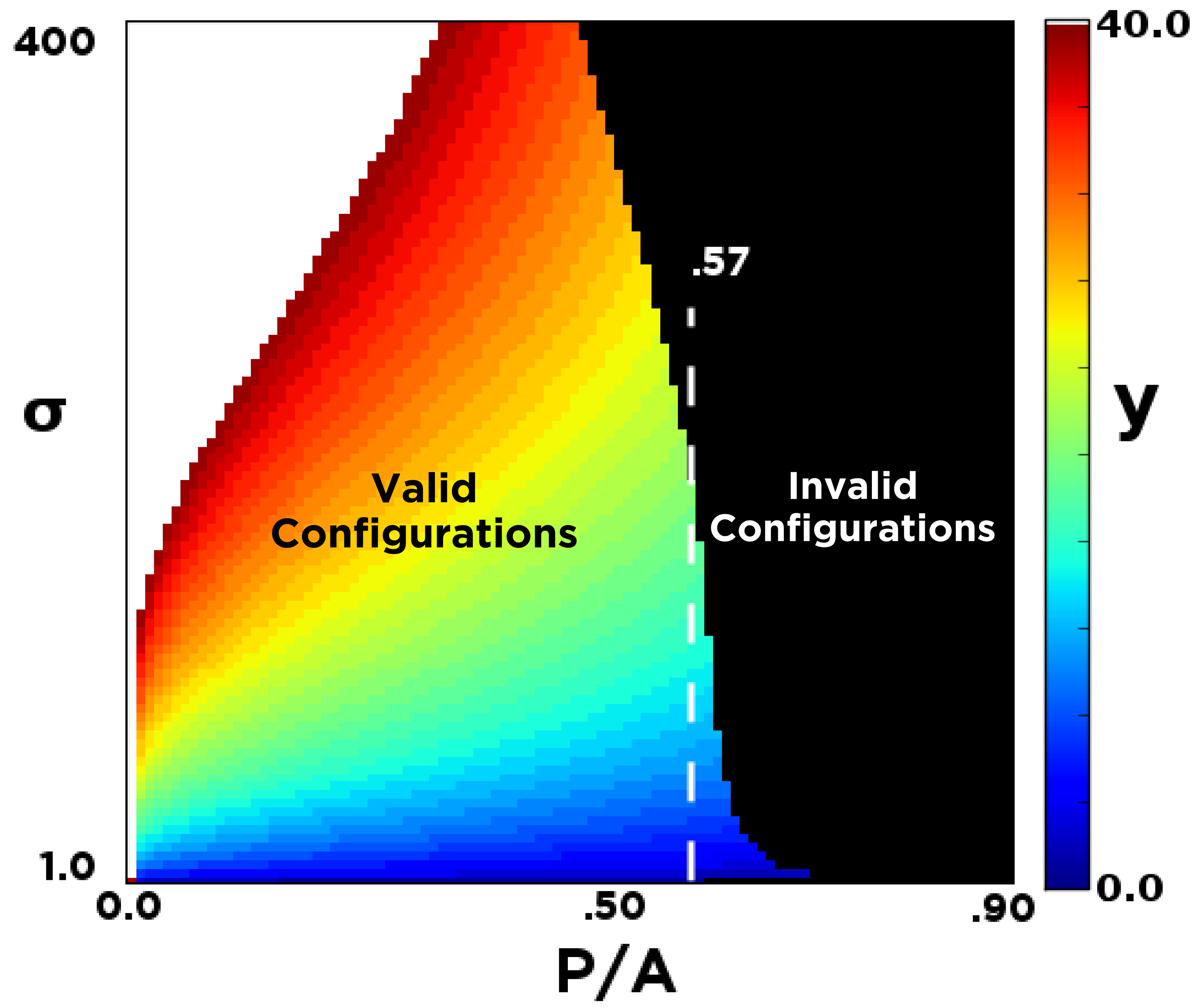
With the path planning problem defined as the above minimization, we want to find values of our parameters to find non-minimal distance paths (i.e. valid configurations).

With a few assumptions, we find that we will get valid configurations when there is a solution to this equation.

$$\frac{P}{A} = \sqrt{\frac{\pi}{2}} \frac{y}{\sigma} \exp\left(- \frac{y^2}{2\sigma^2} \right)$$

While there is no simple form for y, we can determine from this that we want to avoid configurations where P/A > 0.57.

Simulated Results



After planning paths with thousands of different configurations, the resulting relationship between the parameters and y-value gives the above heat map and a general guide for tuning parameters for social navigation systems.