Ambulance Bases

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(Continuous variables, constrained, unknown if it is smooth or not.)

Problem Statement: Calls (i.e., requests for ambulances) arrive according to a Poisson process at constant rate λ per hour. The calls are located within the unit square $[0,1]^2$, where distances are measured in units of 30 kilometers so that the square's area is 900 km^2. Call locations are i.i.d. with density function $(f(x,y) : 0 \leq x, y \leq 1)$ and independent of the Poisson arrival process. Scene times (time that an ambulance spends at the location of the call) are gamma distributed with mean μ_s minutes and standard deviation σ_s minutes.

There are a number $d \geq 1$ ambulances. Each ambulance travels at a constant rate of v_f km/hr on the way to a call, and at a constant rate of v_s km/hr otherwise. (These rates reflect the fact that ambulances have to slow down when going through intersections to avoid creating further accidents.) All travel is in Manhattan fashion, in the sense that when traveling from (x_1, y_1) to (x_2, y_2), the ambulance first travels from (x_1, y_1) to (x_1, y_2), i.e., vertically, and then on to (x_2, y_2), i.e., horizontally. Ambulance i has a base located at the point $b(i)$, $i = 1, \ldots, d$.

When a call arrives, the closest free ambulance travels to the call, spends some time at the scene, and is then freed for further work. If there are no available ambulances when a call is received, the call is added to a queue of calls that is answered in FIFO order. After attending a call, if there is no further work, the ambulance proceeds back to its base.

The goal is to choose the base locations that minimize the (long run) average response time (time from when a call is received until when an ambulance arrives at the scene).

Recommended Parameter Settings: f is proportional to $1.6 - (|x - 0.8| + |y - 0.8|), \mu_s = 45, \sigma_s = 15, v_f = 60, v_s = 40$. The arrival rate λ may be selected at will, and the number of ambulances d chosen accordingly. Obviously, d has to be large enough that the system is stable. A very poor objective function value is $z_{\text{bad}} = 60/v_f$, which is the time it takes the ambulance to travel between opposite corners of the square.

Starting Solution(s): All ambulance bases located at $(0.5, 0.5)$. If multiple initial solutions are required, then select base locations uniformly at random from within the square, independently of one another.

Measurement of time: Number of simulated hours of operation. Take as budget $1000, 10000$. But this might depend on the arrival rate.

Optimal Solution(s): Unknown.

Known Structure: None.