GOING VIRAL

TEAM 10

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Purpose of the Project

Problem Identification

Epidemic outbreaks are a major concern to public health and a strain on resources

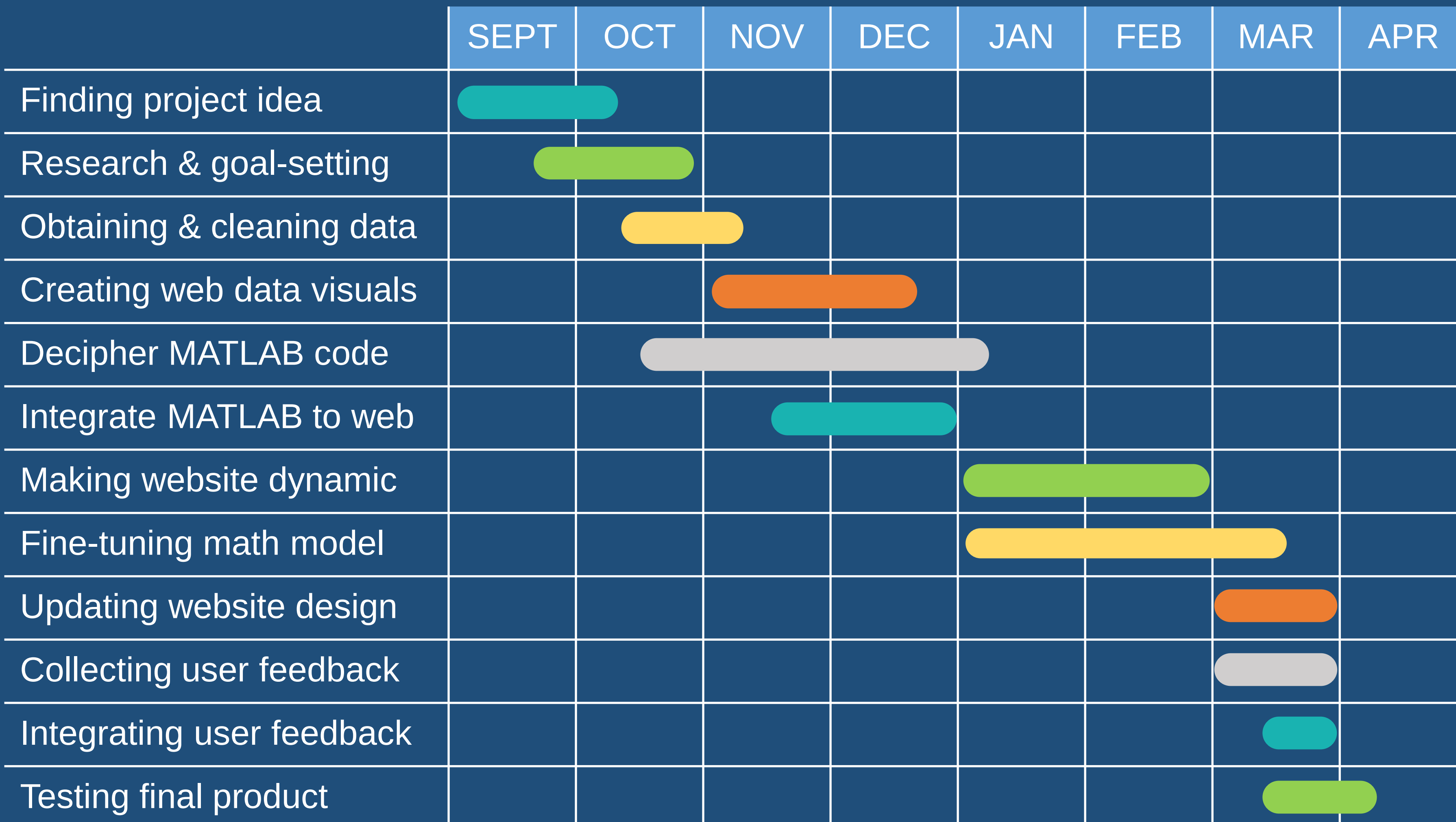
Resource Allocation

Efficient resource allocation saves money and curbs the spread of diseases

Planning Policy Tool

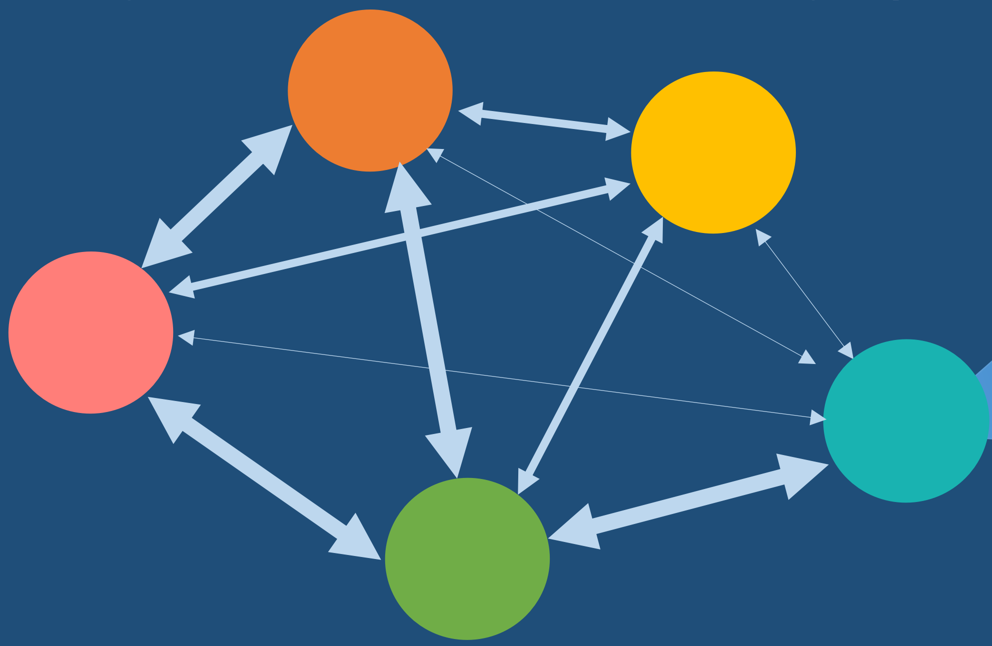
Create a resource allocation policy planning tool represented on a web interface

Yearlong Milestones

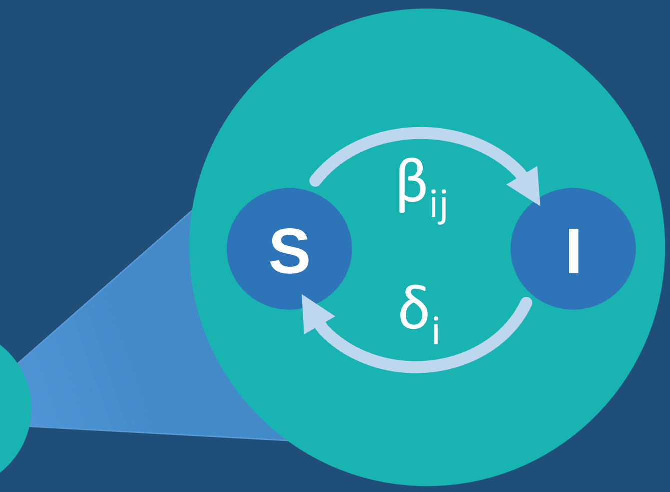


Disease Spread through a Network

Weighted, directed network graph



SIS Epidemic Model



$$\frac{1}{n}\sum_{j\in N_i}\beta_{ij}p_j(t)\leq 1-\left(1-\frac{p_i(t+1)-p_i(t)(1-\delta_i^0)}{1-p_i(t)}\right)^{\frac{1}{n}}$$

Probability of disease spreading depends on how infected the city's set of neighbors are, as well as the recovery rates and the proportions of each city currently infected

Calibrating the Predictive Model

Prediction Model:

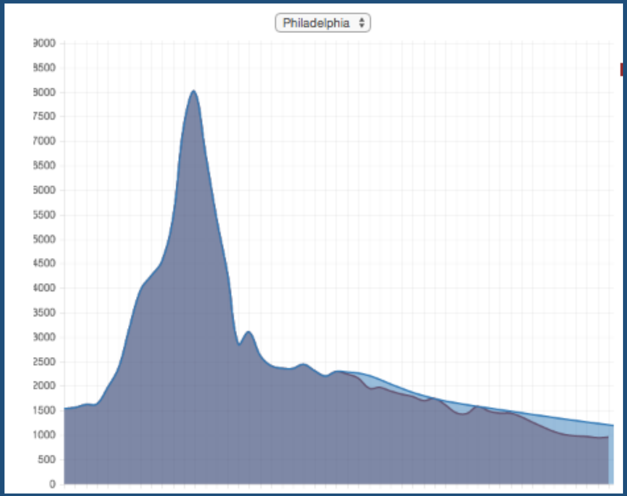
$$p_i(t+1) \le \sum_{j \in N_i} \beta_{ij} p_j(t) + (1-\delta_i) p_i(t)$$

Matrix Formulation:

$$\begin{pmatrix} p_1(t+1) \\ p_2(t+1) \\ \ldots \\ \ldots \\ p_n(t+1) \end{pmatrix} = \begin{pmatrix} \delta_1 & b_{12} & \ldots & \ldots & b_{1n} \\ b_{21} & \delta_2 & b_{23} & \ldots & \ldots \\ b_{31} & b_{31} & \delta_3 & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & b_{n-1,n} \\ b_{n1} & \ldots & \ldots & b_{n,n-1} & \delta_n \end{pmatrix} \begin{pmatrix} p_1(t) \\ p_2(t) \\ \ldots \\ \ldots \\ p_n(t) \end{pmatrix}$$

Solving for Natural Recovery Rates:

1. Initialize a possible set of δ_i values
2. Calculate absolute difference between real & estimated data across all cities and years
3. Repeat steps 1 & 2 for all combinations of δ_i
4. Return set of δ_i values with minimum difference



Resource Allocation Model

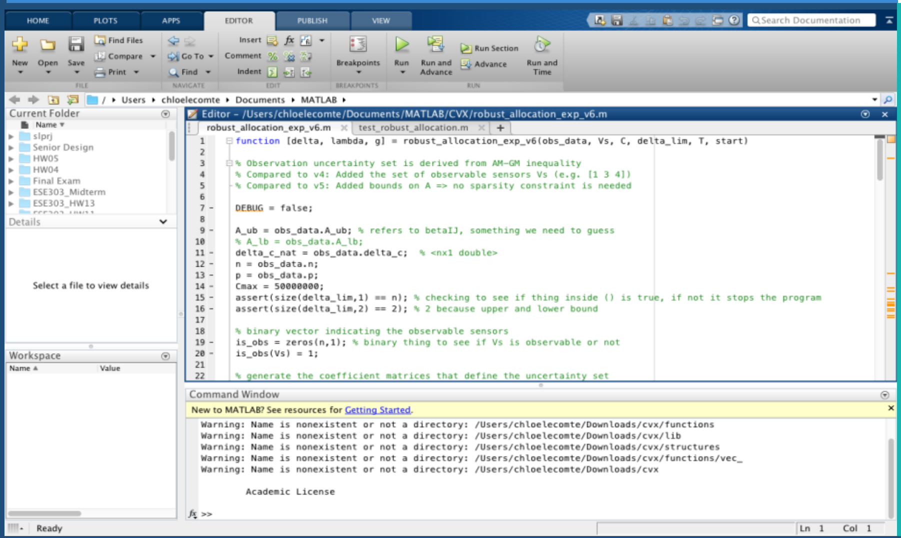
Convex Optimization Problem

- ◇ Local min is global min
- ◇ Scalable for large data sets
- ◇ Faster algorithm
- ◇ Implemented using CVX MATLAB Library

$$\underset{\mathbf{d}^c}{\text{minimize}} \quad \sup_{B_{\mathcal{G}} \in \Delta_{B_{\mathcal{G}}}} \rho\left(M\left(B_{\mathcal{G}}, \mathbf{d}^c\right)\right)$$

$$\text{subject to} \quad \sum_{i \in \mathcal{V}_C} g_i\left(\delta_i^c\right) \leq C,$$

$$\underline{\delta}_i^c \leq \delta_i^c \leq \overline{\delta}_i^c, \quad i \in \mathcal{V}_C,$$

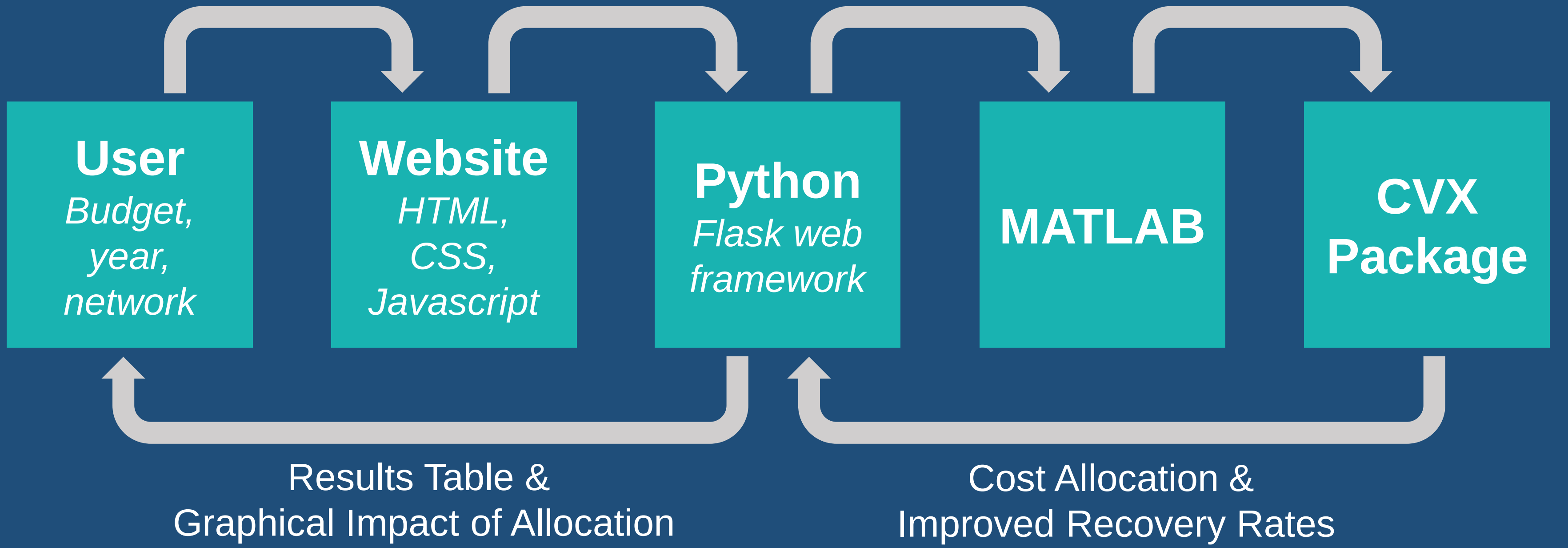


Results

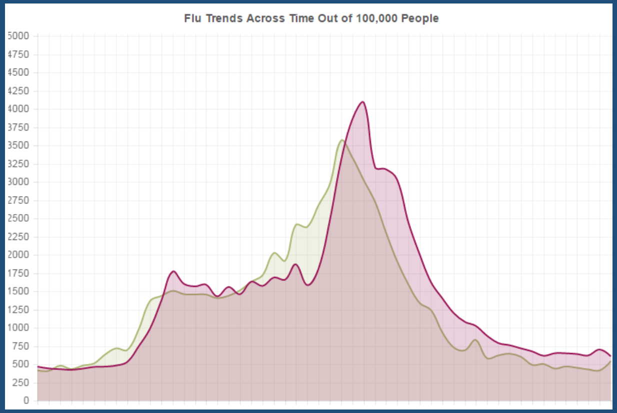
- ◇ Optimal budget allocation
- ◇ Improved recovery rates
- ◇ Cost per infection prevented
- ◇ Graph of projected improvements

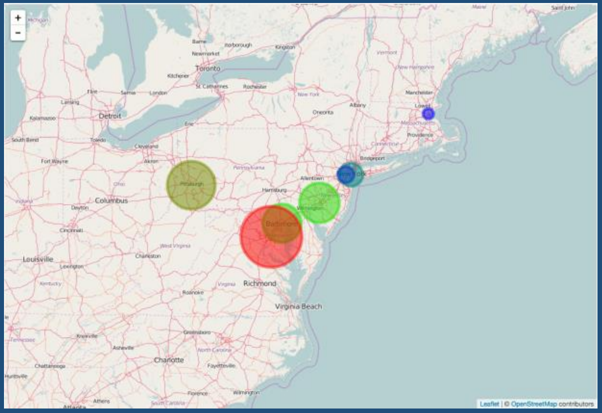
Software Architecture

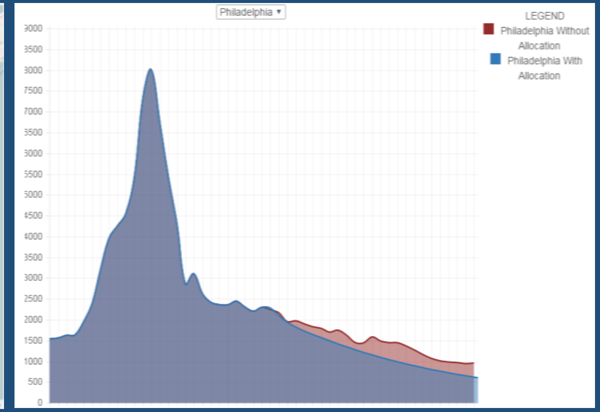
Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Iteration 6
CVXOpt and CVXPy	Python MATLAB Engine	Heroku Deployment	SEAS Server with PHP	Digital Ocean: Ubuntu Servers	Deployment & Redirecting to Domain



Planning Tool Features







Flu Data by City

Graph number of infected people out of 100,000 by flu season and city. Users can interactively graph cities and years simultaneously, as well as view age distributions of populations.

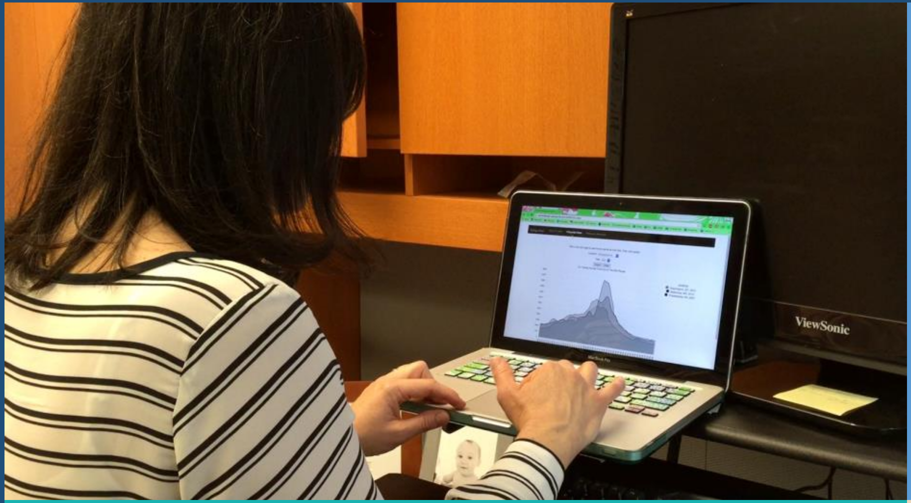
Heat Map

Choose a network of cities and a time period to map. The model calculates which cities' data in that particular network is most correlated with others'.

Resource Allocation

Input budget, year, and network for an outputted graph and table of cost allocations, improved recovery rates, people saved, and cost per life saved for each city.

User Feedback



Sarah Jenkins & Megan Doherty

- ◇ Create results table in Resource Allocation
- ◇ Add age distribution for comparison
- ◇ Rename “Influential Cities” page to “Heat Map”

Heather Klusaritz

- ◇ Add explanatory info on each page
- ◇ Include “How to Interpret Results”
- ◇ Graph flu seasons instead of years
- ◇ Make Heat Map more intuitive