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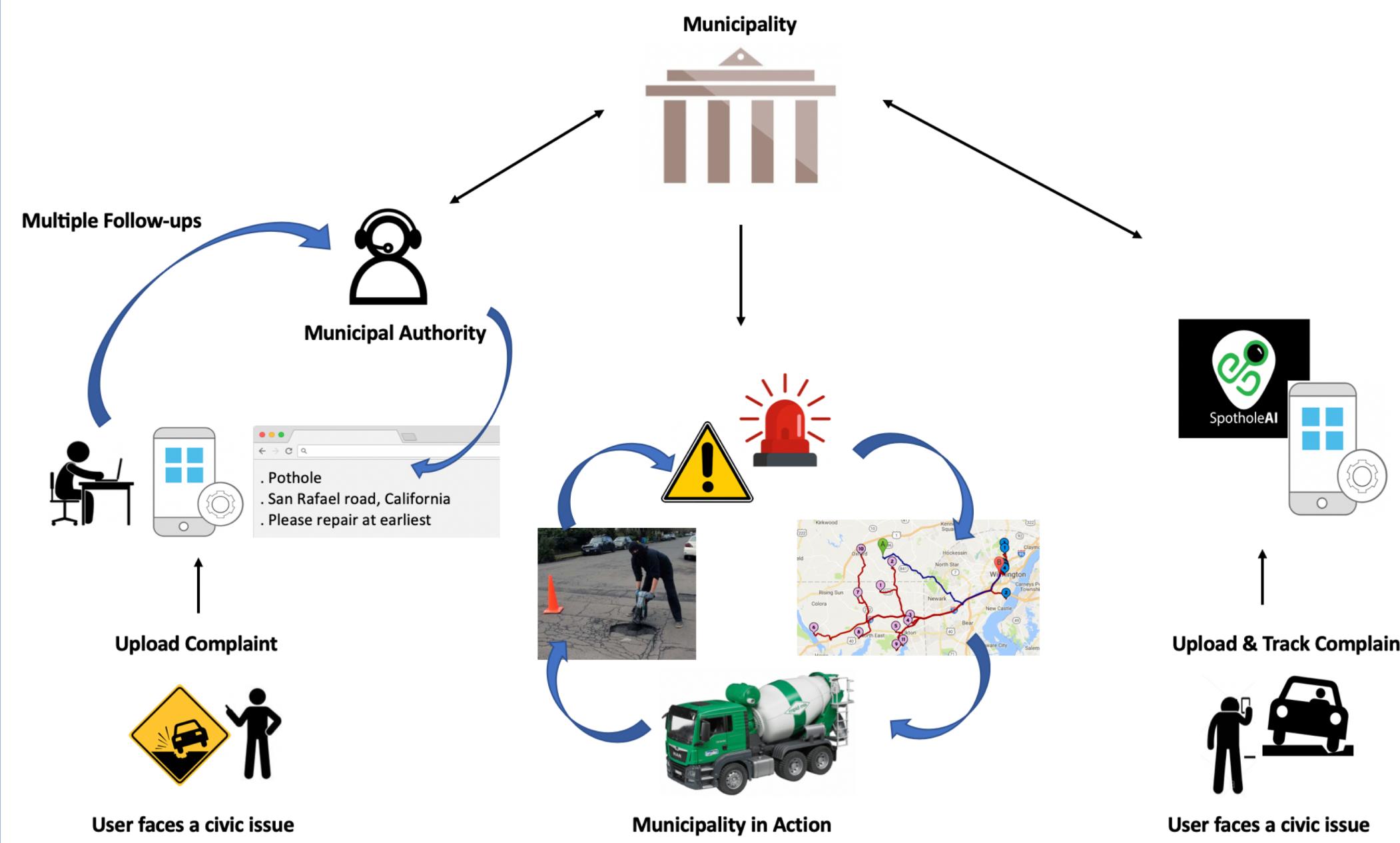
AI for Social Good Workshop, The 36th International Conference on Machine Learning (ICML 2019) - 15<sup>th</sup> June 2019, Long Beach, California, USA.

## Motivation

Current pothole fixing approaches

- 1. Are manual and time consuming [1]
- 2. Require a lot of human intervention at multiple levels

And, the plethora of daily civic complaints at the municipal body necessitates automation



## Related Work

- There exist mobile apps which do detect potholes [2] but that is for a driver to avoid them
- Other apps which help in fixing local civic issues [3] do not incorporate any Artificial Intelligence (AI) to automate the process or cover broad road defects [4]

## Proposal

From any user uploaded image-complaint, SpotholeAI detects potholes and predicts its severity, the raw materials required and the estimated time to fix it, by incorporating Deep Learning for Semantic Image Segmentation methods. The system also proposes an optimized route in order to send municipal services to fix them [5] and intends to reduce the estimated time to report and fix not just potholes but also other civic issues by 10-fold.

## Goals

Under the purview of Urban Planning, SpotholeAI targets the United Nations (UN) Sustainable Development Goals (SDG) of

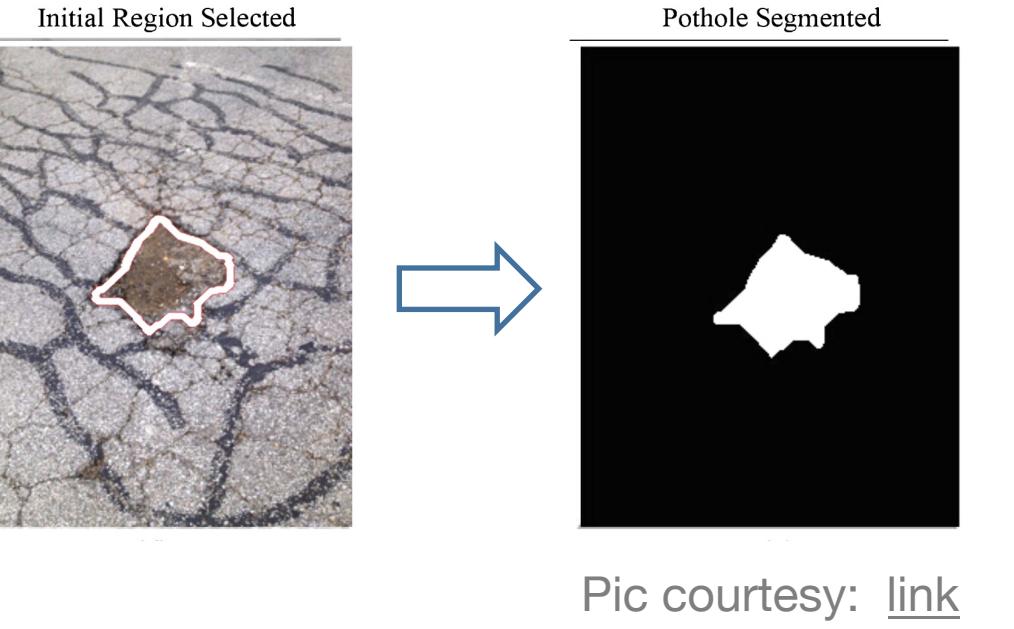
- Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation
- Goal 11: Make cities inclusive, safe, resilient and sustainable

## Impact

- Life-saving application - Reduction in road accidents, Less damage to both human and car
- SpotholeAI tends to create (**s**)heroes
  - Publish good and proactive work to resolve civic issues on social media, radio and print
  - Incentives given to supervising ward officer for fixing potholes with no recurring complaints and also to proactive users who report them
- Transparency and accountability within the civic body
- Instill civic sense in people to proactively report [6]
- Responsibility from civic authorities to fix complaints on time
- Citizen engagement will help build and sustain smart cities [7]

## Technical System

- Pothole image is fed to a Deep Learning based **Semantic Image Segmentation** model that assigns a semantic label to every pixel in the image
- 1<sup>st</sup> work to incorporate AI to detect and fix micro-level problem of potholes in the civic sector
- Transfer Learning of models from Autonomous Driving to the pothole scenario in a multi-task learning setting
- Model Selection: DeepLab [8], Fully Convolutional Network-Based [9], Region-Based [10], Weakly and Semi-Supervised setting [11] and Few-Shot learning [12]

Pic courtesy: [link](#)

## Data

- No existing dataset [13] of pothole images, explore other datasets (Cityscapes, Pascal, ADE20K, etc.) in a transfer learning setting
- Tie-up with the local civic body to collect annotated image metadata. Road contractors have a mobile interface with a photo upload option, drop-down button for catalogue of raw materials along with a corresponding field to enter the quantity, and, to note the time taken in hours, creating a database and annotation tool similar to LabelMe [14]
- One time activity and more data accumulates as the app gets a widespread reach and more users upload image complaints
- Image Augmentation libraries (e.g. Augmentor 3) to scale images
- Vision to create an open-source pothole dataset on the lines of
  - SYNTHIA - a large-scale synthetic dataset for semantic segmentation of urban scenes [15] and
  - Kitti Road dataset
- Prior approval from the local body to avoid privacy concerns

## Labels

- Collect annotated image data wherein each image is
  - Firstly segmented to highlight area of interest (say potholes)
  - Labeled with information on its severity, the raw materials required as well as the estimated time to fix it
- Label the pixels of a pothole in images using
  - A Fully Convolutional Network (FCN)
  - Curve-GCN [16] for efficient interactive annotation using semi-supervised approaches
- Offset annotation cost, by labeling both
  - Coarse (only object bounding box labels) and
  - Fine-grained (having semantic segmentation labels and box labels)
- Resulting dataset will have a small set of fully labeled and a large set of weakly labeled images
- Crowd-sourcing is an option for segmentation, but domain expertise from the civic body as well as a road contractor is required for label information

## Mobile App Screens

**User Scenario**

Report New PotHole  
To report a pothole, please upload the image of the pothole  
UPLOAD IMAGE

uploads image-complaint on the app (which is geo-tagged in the background)

**Municipal Ward Supervisor**

All Complaints  
Complaint\_Id: PH\_00654  
Status: Completed  
Complaint\_Id: PH\_00655  
Status: In Progress  
Complaint\_Id: PH\_00717  
Status: Initiate  
Complaint\_Id: PH\_00704  
Status: Follow-up

Pothole Summary  
Complaint\_Id: PH\_00654  
Supervising Officer: Mr. Sambhaji Jadhav  
Jurisdiction: Ward 27  
Status: Pothole repair started  
Report Date: 06 Jun, 2018  
Pothole Severity: Low  
Raw Materials: Small stones, tar, cement  
Estimate Time to Fix: 2 days  
GPS: 19.0760° N, 72.8777° E

Route Planning  
India Post, GAWAND BAUG, MANPADA, GLOMAX WonderMall, SETHANY Hospital, Pochanai Rd Number 2, Jupiter Hospital Thane, Shree Ayyappa Temple, Baba Temple Vartaknagar, Google

Repair Completed  
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Note: I could not make it to the workshop but would like to thank the ICML-AISG organizers for allowing me to present this work. Please feel free to reach out for collaborations on vishal.bhalla@tum.de

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Access to paper

## Evaluation Methodology

- Opportunity to conduct a Proof Of Concept (POC) with the local municipal body to test the proposal and fine tune the product
- Close co-operation with the civic authorities, utilizing domain expertise from road contractors through direct interactions and site visits
- Initial experiments to identify which issue needs priority as well as the right severity levels and raw materials needed for the pothole fix
- Establish a standard - Use this template globally, across civic bodies
- Measure success as the turnaround time from reporting to fixing a civic issue

## Risks

- Actual on-ground severity differs. Supervisor provides feedback in mobile app so that the model learns and betters its predictions
- Government or municipal authorities do not buy this product
  - As it brings in an additional transparency factor OR
  - Another civic issue needs to be fixed on priority instead
- Model should be robust to handle image blur, especially when driving – use frames in video mode as an option
- Blur any user identity (a person's face or a car license plate) to account for privacy [3]

## Extensions

- Same technical setup to resolve other civic issues like garbage disposal, tree fall, choked drains, water pipe burst, etc.
- Extends to highways, airport runways for safe landing and in defense for rescue and emergency operations wherein a drone sweeps the area to get an image scan, or even leverage the availability of high-resolution satellite imagery [17] instead of a user's mobile camera
- Under-belly cameras already installed in a vehicle or public transport like buses, that will give live road status as a future modality

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