Crowdsourcing and Cloud Computing Towards Trustful Pavement Condition Ranking

ZhiQiang Chen, PhD
Assistant professor of civil and computer engineering
University of Missouri, Kansas City; Email: chenzhiq@umkc.edu

Yueying Bian
President GreenBeanCity, Inc. Email: yybian@gmail.com

UMKC School of Computing and Engineering

Scope

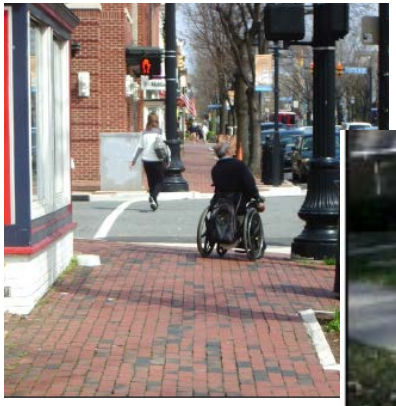
- Focusing on pedestrian pavements
- Using crowdsourcing (human computing) as a general means to reporting, assessing, and managing pavement condition

Outline

- Pedestrian pavement condition
- Related inspection technologies for pavement
- Why Crowdsourcing?
- A new paradigm – Mobile-cloud computing aided crowdsourcing
- Preliminary Performance Evaluation
- My Vision and Conclusions

Pedestrian Pavement

- Everyone is a pedestrian
  - *Crowdsourcing basis*
- Equally as important component as highway/street pavements
  - *Crowdsourcing incentive*
- Lost cost to construct; relatively high cost to maintain
  - *Motivation for using crowdsourcing as an alternative technology*



(Huber et al; FHWA SA-13-037)

Pavement Inspection Technologies

- Visual inspection
  - Predominant to date;
- ‘Automatic’ inspection technologies
  - Guralnick et al 1993; earlier imaging technique
  - Wang 2000; vehicle mounted at highway speed
  - Li et al 2000; 3D scanning
  - Huang and Xu 2006; real-time imaging processing
  - Lu et al 2013; rapid and mobile acoustic surface wave
- **All methods involve professional training, equipment, and usually feature high cost**

General Promises of Crowdsourcing Technology

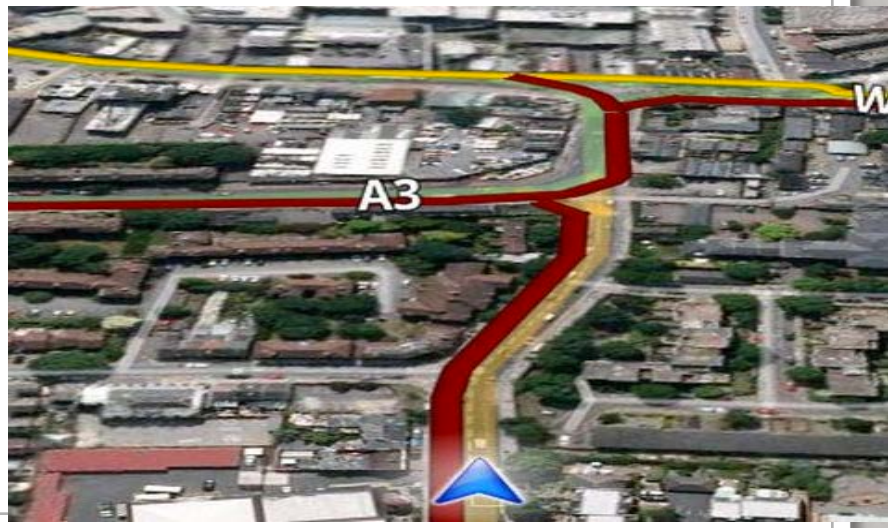
- Real-time or Rapid problem solving
  - Enabled by the ubiquitous use of smartphones, wearable computing devices, social networks, and connection via 3G/4G cellular networks
- Highly intelligent processing
  - Humans are better than existing computer-based analysis; especially for recognition of highly complex visual patterns

Types of Crowdsourcing

- **May categories; for example (Liu 2014)**
  - **Crowd-Feeding:** active, two-way feedback loop where information or tasks conducted by the crowd are fed or shared back to the crowd.
  - **Crowd-Harvesting:** passive and one-way gathering of data to search for information from the crowd information.
  - **Crowd-Seeding:** strategic and one-way request that pre-identifies certain members in a crowd to source from and empower them with tools.
  - ***Crowd-Sourcing*:** active and one-way request between the crowd and entity requesting information from the crowd (the crowd-sourcer).

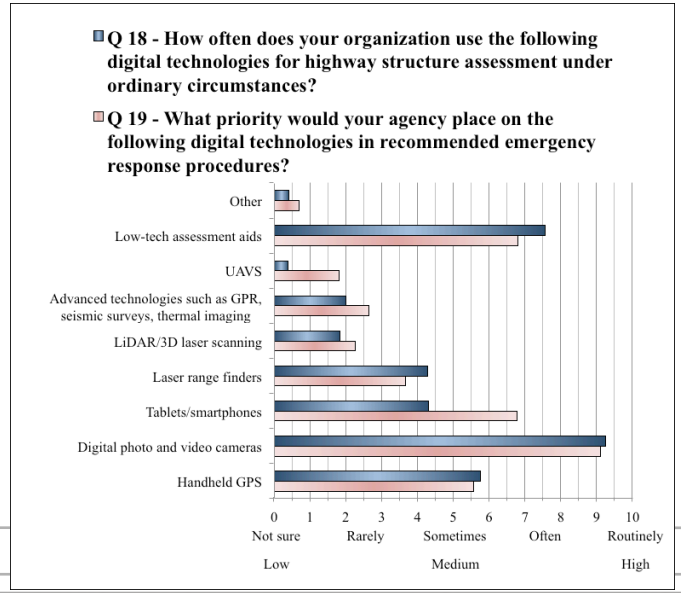
Crowdsourcing for Transportation-related Applications

- OpenStreetMap – probably the largest crowdsourcing project in the world
- Google Map Traffic – 'borrow' your position information when you drive and use Google Map for navigation (when turned on)



Smart Technologies for Transportation Assessment

- NCHRP-14-29 Questionnaire from 50 states' DOT officials indicated strong interest in using mobile technologies for transportation structure assessment.
- Smart apps aided mobile-cloud computing are acceptable for transportation agencies
- ***Crowdsourcing or enabling the public for transportation structure assessment?***

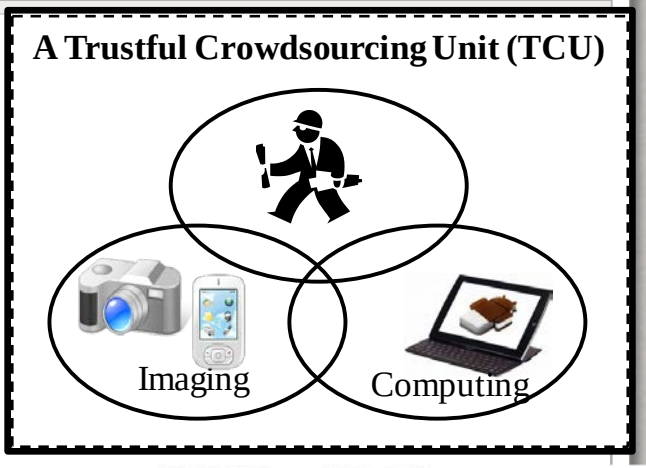


Challenges of Crowdsourcing Technology

- Towards making real-time crowdsourcing-based pavement or in general built environment assessment:
  - Truthfulness: taken by users who volunteer and commit the responsibility
  - Relevance: reporting **imaging-centric data** related to pavement conditions
  - Quality: reporting metadada ready for advanced extraction and quantification of damage
- Other Perspectives
  - Data provenance or
  - Unstructured data to structured data
- Big Data issues (when scaled up)

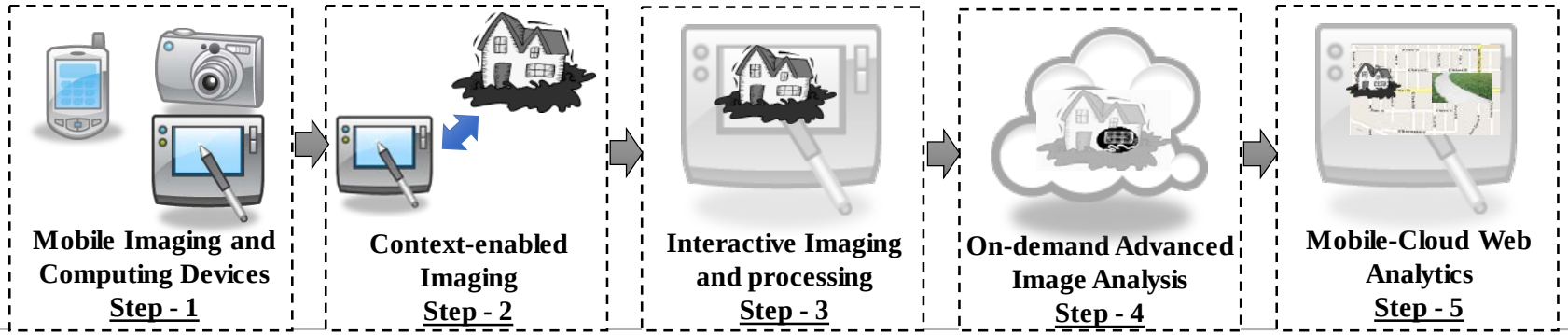
Our Solution – Collaborative Mobile-Cloud Computing (Chen et al 2013)

- Active, strategic and two-way crowdsourcing through smart apps and mobile-cloud computing infrastructure
- Front-end: users with smart apps that realize 'human' sensing and computing
  - Trustful, relevant and quality
- Back-end: a mobile-cloud computing infrastructure that serves the front-end and the users

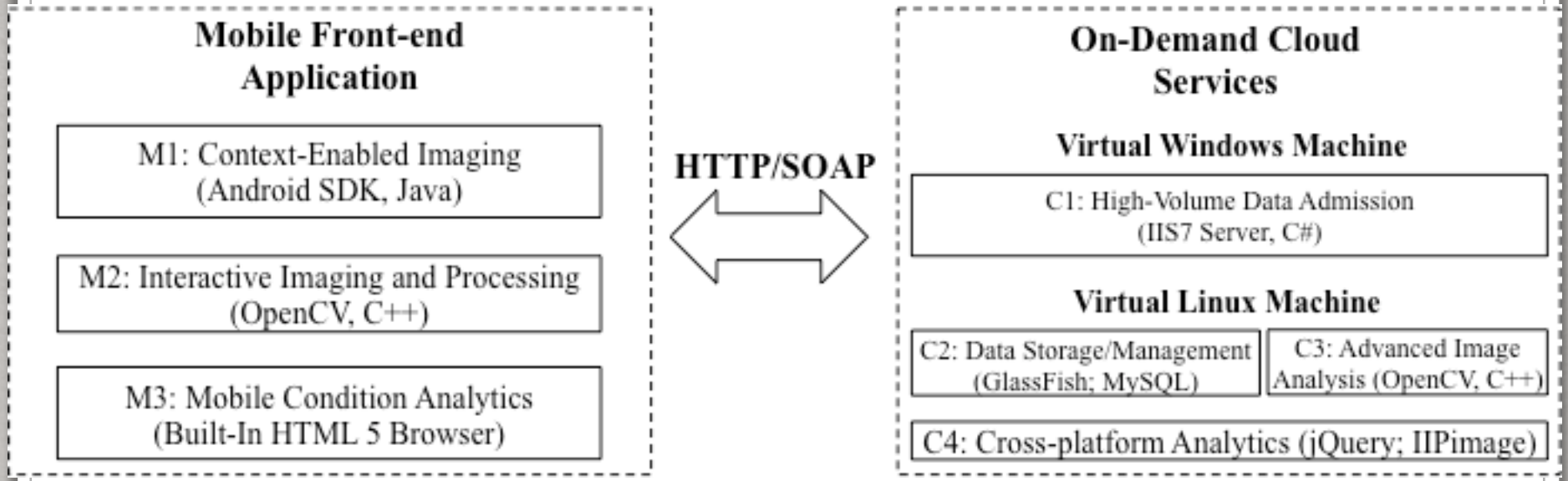


Collaborative Mobile-Cloud Computing

- An emerging and still-advancing computing paradigm!
- Proposed a CMCC framework for crowd-based Civil Infrastructure Condition Assessment
  - Context-enabled imaging
  - On-demand cloud-based image analysis



Basic System Design

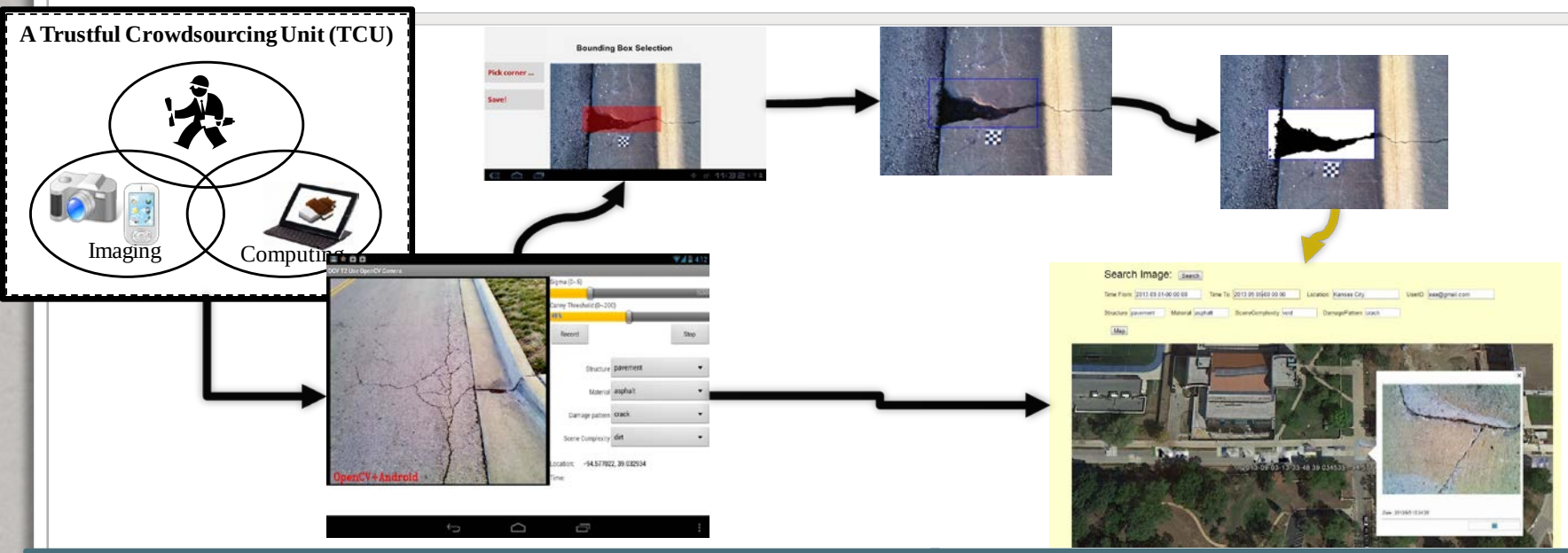


- Using Android smartphones, tablets, and digital cameras as the front ends
- Using IBM Smart Cloud as the cloud infrastructure
- Android SDK and OpenCV to develop mobile fronts: context enabled imaging/computing
  - Other potential enabling technology: natural language processing
- Using OpenCV to implement vision algorithms
  - Other potential enabling technology: Hadoop-based big data management and basic processing

Development and Implementation

- We have developed a prototype system
  - Using Android smartphones, tablets, and digital cameras as the front ends
  - Using IBM Smart Cloud as the cloud infrastructure
    - Android SDK and OpenCV to develop mobile fronts: context enabled imaging/computing
      - Other potential enabling technology: natural language processing
    - Using OpenCV to implement vision algorithms
      - Other potential enabling technology: Hadoop-based big data management and basic processing
    - jQuery Mobile, HTML5, Google Map APIs for disaster damage mapping and analytics

Operational Flow



Context-enabled Imaging

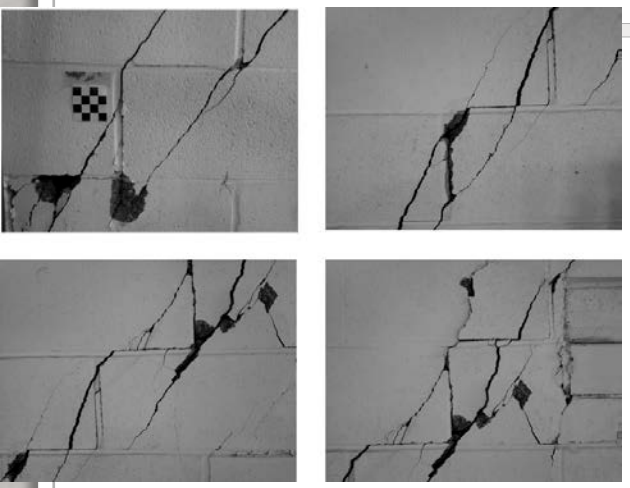
- Imaging with the best of view
- Interactive context-data input: gesture/voice
  - Damage types (crack/pothole)
  - Pavement types/materials
  - Bounding box of specific damage patterns

Collaborative Mobile-Cloud computing

Mobile computing in the background

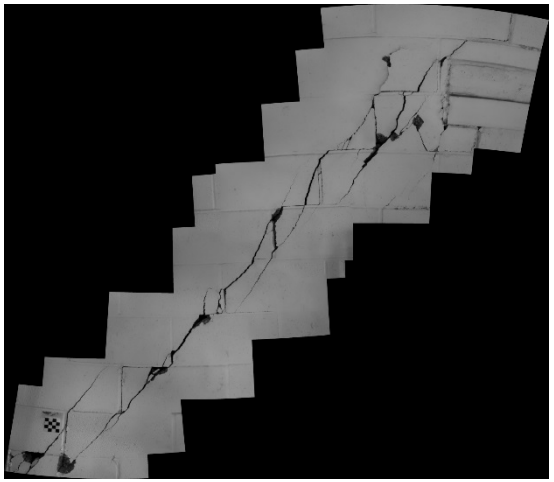
- Context-aided processing in the Cloud
- Hosting of damage analytics for the mobile ends

Reporting of A Long crack Using multiple images

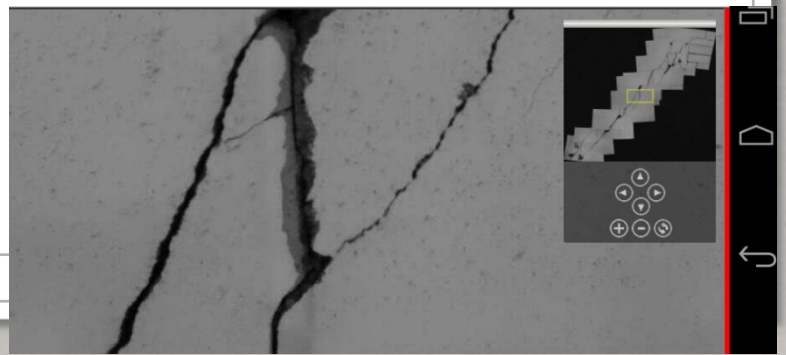


Video stream data
From a mobile phone

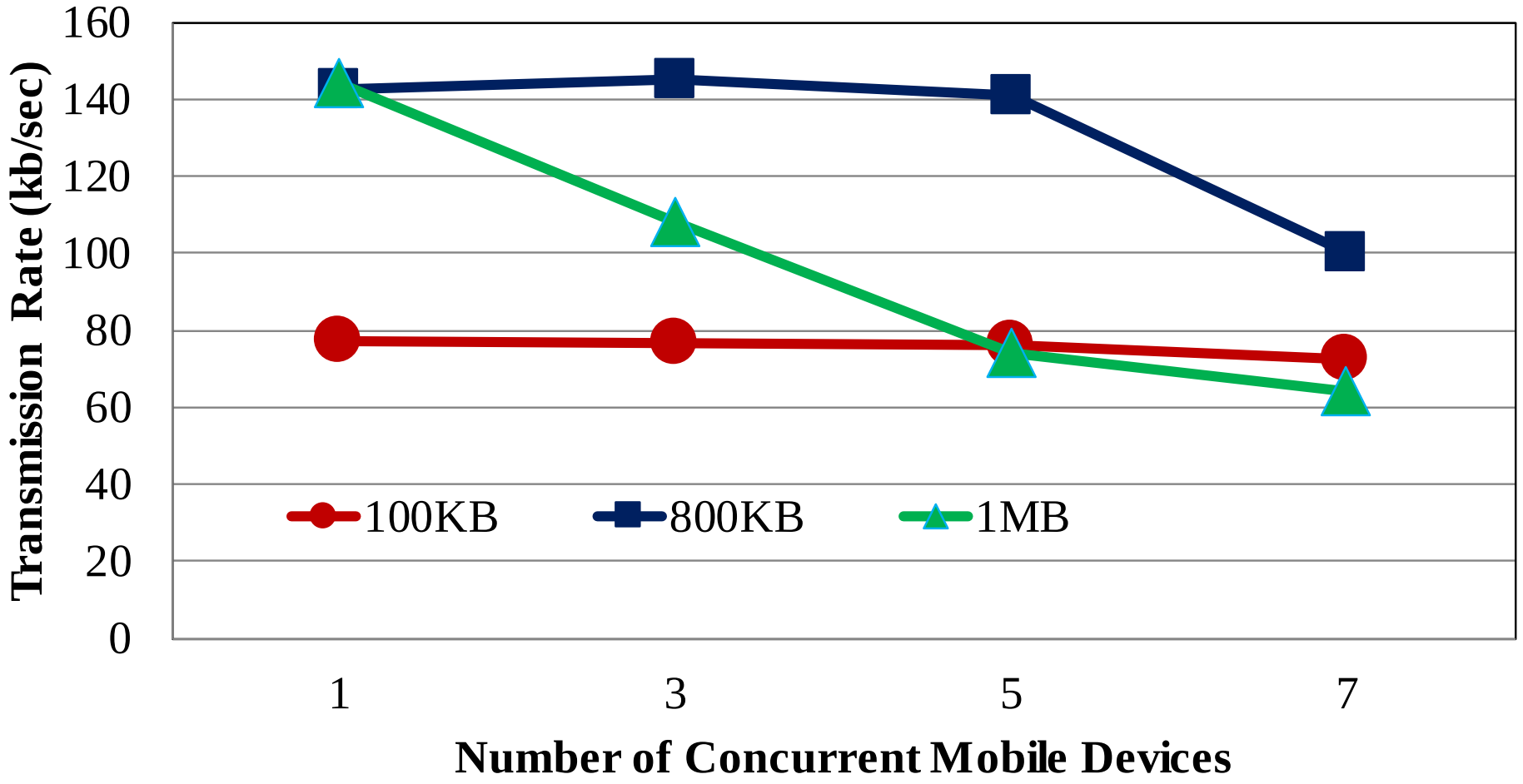
Cloud processing
(image stitching)



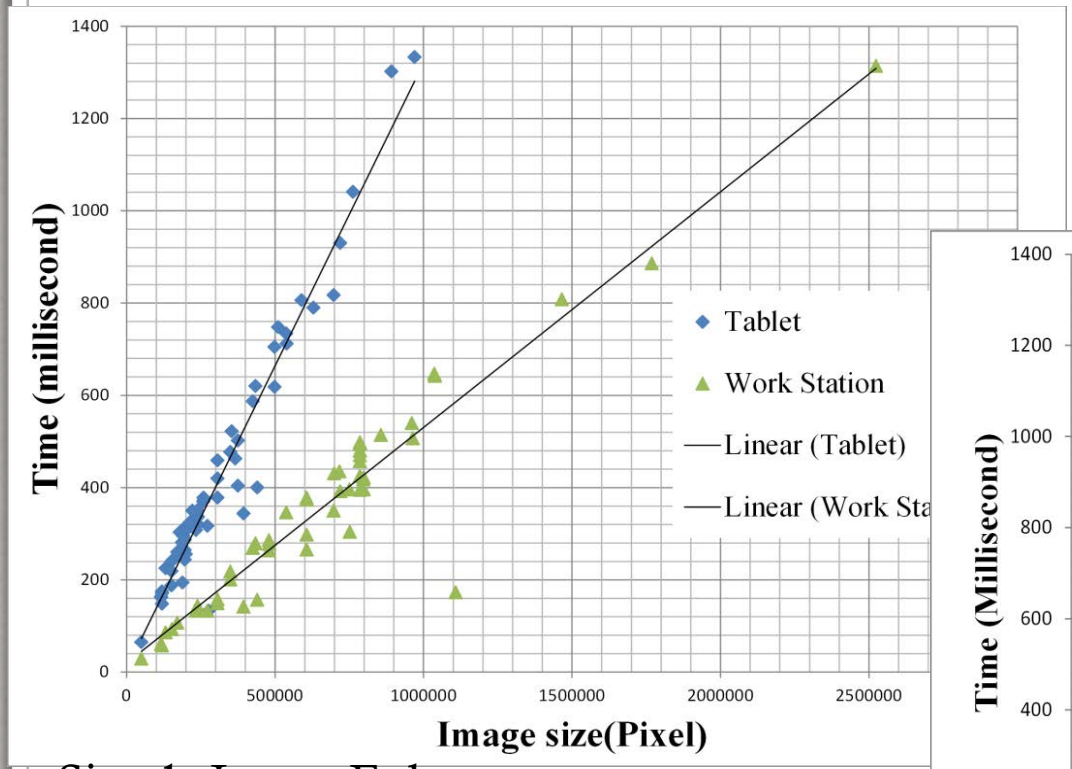
GIS Gateway for
visualizing the damage



Performance Evaluation: Concurrent Imagery Transmission

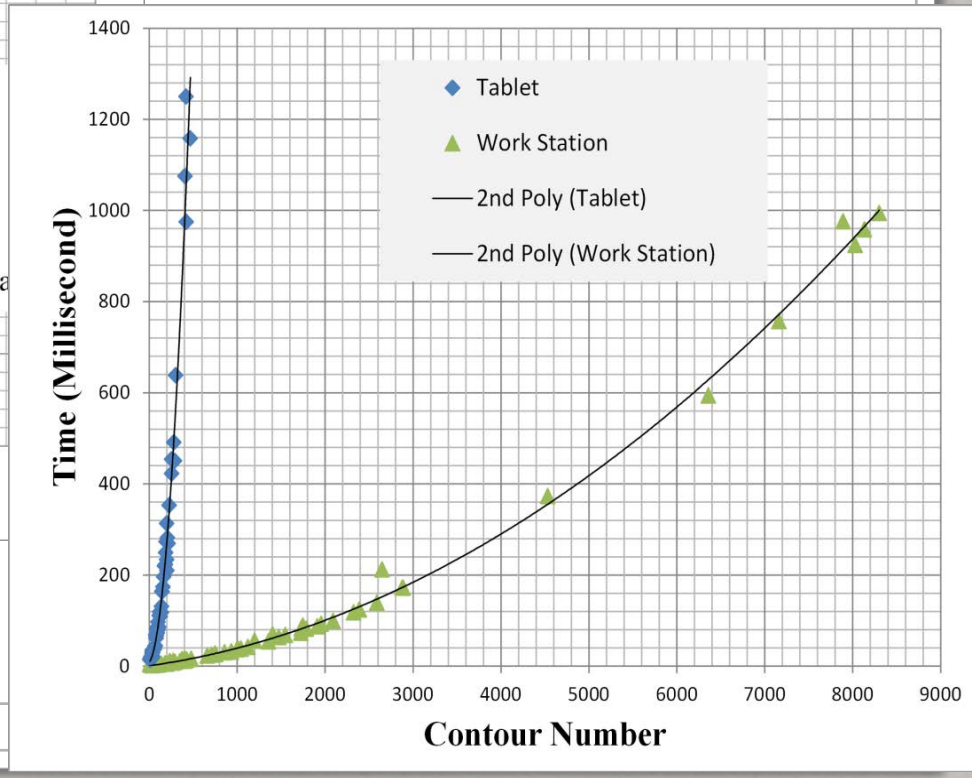


Mobile Processing Performance



Simple Image Enhancement

Simple Contour Detection and Damage Quantification



Conclusions and Vision

- Crowdsourcing – tremendous potential for realizing pedestrian pavement damage mapping
- Because of its imaging-centric nature, a mobile-cloud paradigm shows promises
  - The mobile end fulfills trustful and relevant reporting
  - The back-end servers realize high-performance computing, data processing, and GIS-based analytics
- A crowd-based pavement ranking system?
  - As possible and feasible as Google Traffic and OpenStreetMap

Thanks much!