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Camera Phones with Pen Input as Annotation Devices

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Camera Phones with Pen Input for Generating Digital Annotations to Real-World Objects

- Interaction possibilities of camera phones with pen input
- Techniques for anchoring digital annotations with physical objects
  - visual codes for annotations of items in printed photos
  - annotations by visual appearance using image matching
- How can a mobile user interface for a generic annotation system be structured?
  - creation, access, sharing, organization of annotations

Outline

- Introduction
- Digital Annotations with Visual Codes
- Sign Annotations with Image Matching
- Open Questions

Digital Annotations to Physical Objects

- User-generated digital media linked to physical objects
- Embed digital information into the real world
- Can be shared across space and time
- Can take multiple forms
  - Text, graphics, audio, video, hyperlinks, vCard, vCalendar

Content of Digital Annotations

- What questions do annotations answer?
  - what are similar objects?
  - what are complementary objects?
  - what similar objects are better / worse?
  - who else likes this object?
- Ratings
  - using attributes that are specific for the object class
  - uring attributes of a taxonomy or ontology

Requirements of Annotation Systems versus Camera Phone Features

- Identification of physical objects
  - camera and image processing, barcode readers, RFID / NFC
- Graphical annotations of physical objects
  - marker-based registration
- Sharing annotations and getting up-to-date information
  - wireless connectivity
- Handle annotations in multiple media types
- Availability in everyday settings

Benefits of Pen-Based Input

- Fine-grained annotations for objects captured with the camera
  - draw frames around items
  - draw arrows to give directions
  - put predefined icons onto object images
- Interactive support for image matching algorithms
  - telling to the system what items are important
  - segment foreground from background

Problems of Mobile Input

- Simplify creation of digital annotations
  - avoid text input
- Classification in a taxonomy
  - selection within taxonomy
- Widgets for entering parameters
  - ratings
- Forms with attributes that are specific to the objects class

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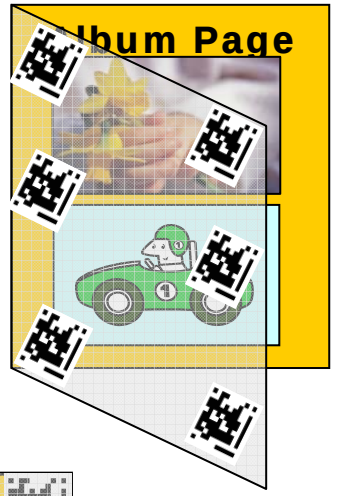
Annotating Photos in a Physical Album

- Attach media to a physical photo album
- Mobile annotations: voice, text, music, files, links
- Platform:
  - Smartphone (T-Mobile MDA III)
  - Windows Mobile 2003
  - Pen-based input
  - Camera-equipped (640 x 480 pixels)

Annotating Photos in a Physical Album

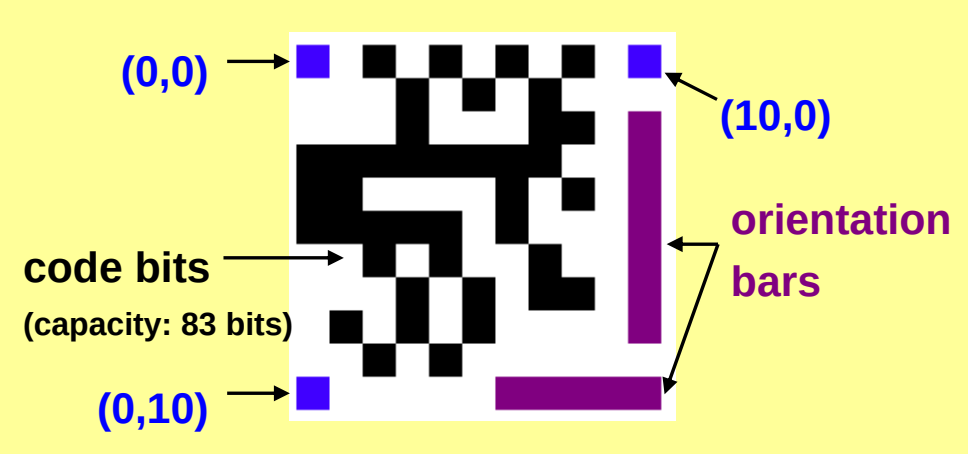
- Two-dimensional markers (Visual Codes) attached to foil covering album pages.



- Annotation process:
  - Take picture of page
  - Draw polygon around object
  - Attach media
  - Store polygon and media on server

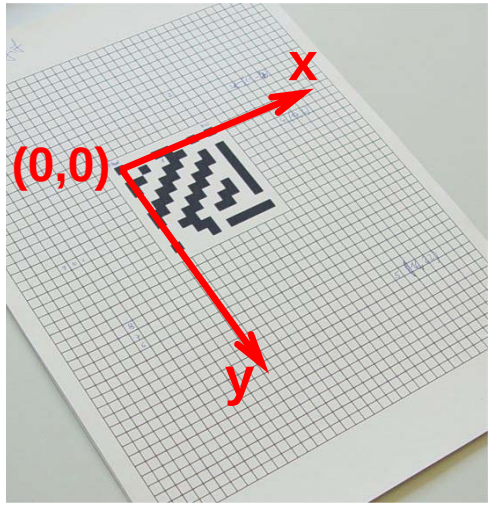
Visual Codes for Camera Phones

- For low-resolution phone cameras
  - e.g. 160x120 pixels in view-finder mode
  - requires coarsely grained code
- Arbitrary orientation because of camera mobility requires special code features
- Lightweight recognition algorithm

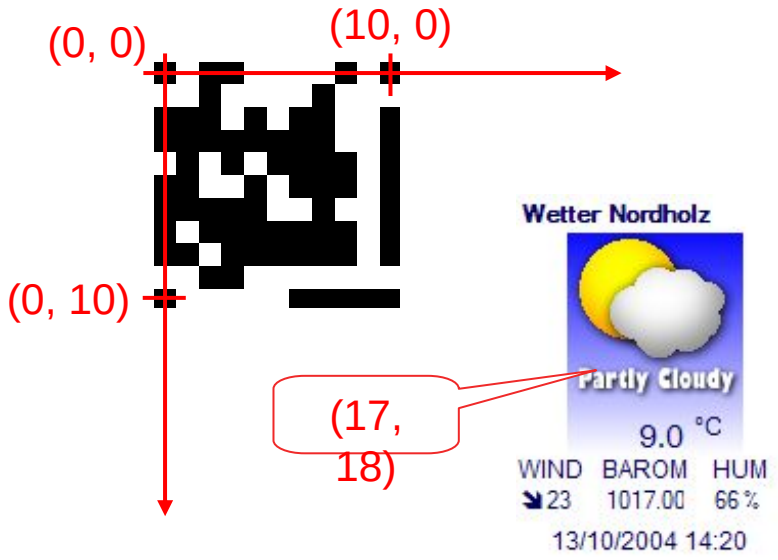


- Storage capacity
  - 76 bits / 96 bits
  - error detection (83,76,3) / (103,96,3) linear codes

Code Coordinate System



- Each visual code defines a local coordinate system
  - invariant to projective distortion
- Projective mapping (planar homography)
  - convert image pixel coordinates to code coordinates
    → create annotation polygon
  - convert code coordinates to image pixel coordinates
    → display annotation polygon



Annotation Process

Issues with Current Implementation

- Marker size: 2 x 2 cm
  - Higher resolution (1 vs. 0.3 megapixel)
- Number of markers per page (6)
  - Large distance between phone and code: code not readable
  - At least one code must be visible if camera close
- Each code has its own coordinate system
  - User must initialization code cluster
  - Allows for the transformation of coordinate systems
  - Alternative: codes pre-printing at fixed positions

Outlook

- What else to annotate...
  - X-ray images
  - Construction plans
  - Crime scenes

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Annotations by Visual Appearance

- Attaching markers is sometimes not an option
  - visual markers might be too obtrusive
  - objects not under the annotator's control
- Recognize objects based on their unmodified visual appearance

Annotations by Visual Appearance

- Many regular / quadrangular shapes in urban environment
  - street signs, shop signs, indication panels
  - facades of buildings
- Use signs as annotation anchors
  - interactively supported image matching

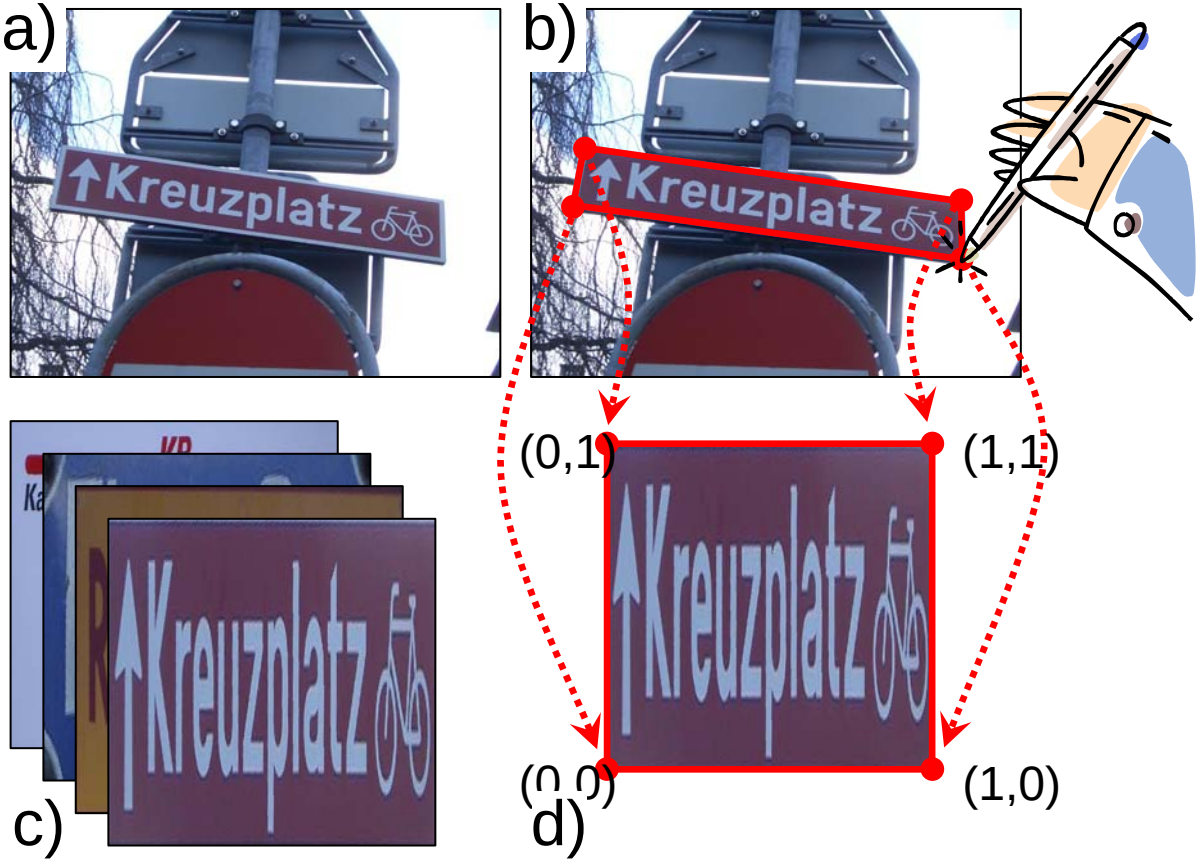
Annotating signs using camera phones with pen input

a) captured photo

b) framing a sign with the pen
- object selection
- segmentation

c) set of templates

d) mapping framed area to unit square



Four-Point Correspondences

- Perspective distortion of sign in camera image
- Project framed part into unit square
  - frame corners correspond to corners of unit square
  - unique planar homography (projective transformation matrix)
  - scale unit square to fixed-size request image of 480x480 pixels

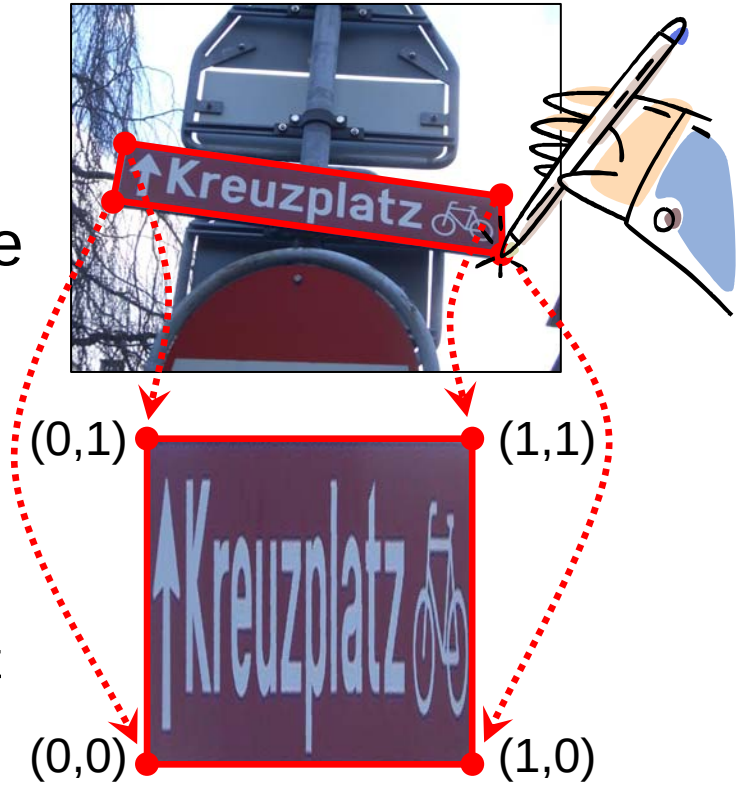
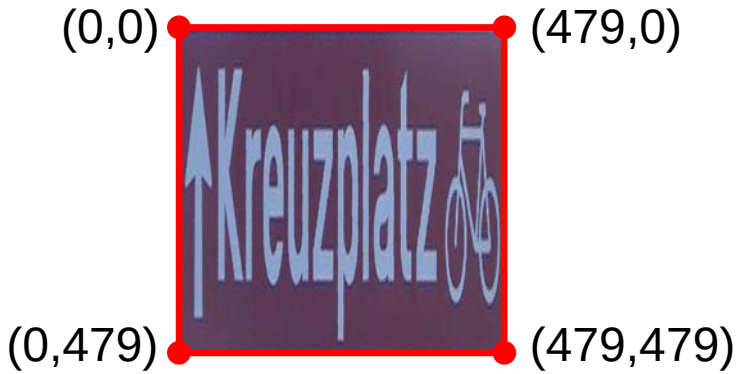


Image Matching

- Request to backend server
  - request image (480x480 pixels)
  - context parameters
    - GSM cell IDs
    - time of day (morning, noon, afternoon)
    - weather conditions (sunny, cloudy, rainy)
- Backend server
  - stores shared annotations and templates
  - executes matching algorithm



Request image

Set of templates

Image Matching

- Matching algorithm
  - sum of pixel-by-pixel differences of hue value of request image and template images
  - template images filtered by context parameters
    - cell IDs, time, weather conditions
  - filtering limits search space to a few dozen candidates
- Initial experiments show that matching works
  - problem: signs are very street similar and are not unique
  - shop signs show more variation in visual appearance

Usability Issues

- Approach is beneficial if it is less effort to take snapshot and tap corners than to enter a unique descriptor
- Upload of request image takes some time
  - less problematic in the future
- A conscious effort is required by the user
  - no automatic detection of annotations
  - no augmented reality
- Usability study necessary in some application context

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Open Questions

- How accurately do users draw frames?
- In what way do imprecise frames degrade performance?
- Are there better image matching algorithms?
  - that require less interactive support
  - that don’t require interactive support
  - that are tolerant against imprecise user input
- What are compelling applications?
  - pervasive urban games? restaurant recommenders?

Summary

- Creating annotations of physical objects using camera phones with pen input
- Camera phones fulfill technical requirements
  - object identification, online connectivity, multiple media types, availability in everyday situations
- Pen-based input allows for fine-grained annotations
- Marker-based approach
  - annotate items on a printed page
- Interactively supported image matching approach
  - annotating unmodified objects

Thank you!

Questions?

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