Mobile AR: Promising innovation or misplaced trust?

Conference or Workshop Item

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Mobile AR: Promising innovation or misplaced trust?

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Outline

• Importance of landmarks for visual navigation
• Principles of Augmented Reality (AR)
• Registration
• Augmented Reality at sea
• Measuring deviation (compass error)
• The results
• Implications
• A possible approach
• Conclusions
Visual navigation

• Important in the air, on the sea, in open country
• Depends crucially on identifying landmarks
  • Either to “fix” position
  • Or to define (approach) direction

• Traditionally
  • Chart / map
  • Binoculars
  • (possibly) sailing / flying / walking guides / directions
Recognizing landmarks

• The chart shows three “conspicuous buildings” on the coast here –
  • But which are they?

• NB: the “mega” building isn’t one of them
  • That didn’t appear on the chart until about 3 years after it was built
Electronic navigation to the rescue?

• GPS (fixed) can tell you your position and velocity
• Handheld devices that are both location and aspect (i.e., which way the device is facing) aware *should* be able to help identify landmarks
• Or even do it for you
  • Adding markers to camera image
• Augmented Reality
Principles of AR

• 2-D for simplicity
• Known position...
• .. And aspect
• Known relative position of Point of Interest
• Known camera field of view
• Place marker within camera image
etips travel guides (2012)  https://www.youtube.com/watch?v=a90DDQZmGj4
AR in urban environments - challenges

- GPS poor
  - Canyon effect, multi-path, screening, interference
  - 5m accuracy optimistic
  - 5m position error @ 50m ≈ 6°

- => “Registration” of camera image
  - Limited – no universal 3D model
    - Although there are topographic maps at smaller scales
  - Look for vertical edges, match against building footprints
  - Relies on limited information
    - Easily confused – e.g., by recessed doorways, canopies, lamp-posts, trees ...
Milton Keynes Centre...
Milton Keynes Centre
Augmented Reality at sea

• Vertical edges in short supply
• Coast relatively distant - ~ 1 Nm
  • Small vertical angle within image
    • 100m cliff at 5 km is about one degree of vertical angle
    • Field of view ~ 30 degrees

• Large open spaces
  • Few nearby objects (apart from the odd wind farm or navigation buoy ....)

• And everything is MOVING....!
Registration at sea?

• Challenging –
  • Foreground moving (waves)
  • Coast / clouds – if any – moving (motion of vessel)
  • Whole image moving – trying to hold a tablet still as the boat moves...
    • And the pattern of motion is almost designed to completely confuse inertial sensors
  • Not many distinguishable edges
    • Might be able to use headlands – if there are any
    • But they’re still moving
  • So reliant on built-in sensors
    • GPS – for position – probably OK.
    • Compass for aspect
Smartphone / tablet compasses

• Claim incredible precision...
• ... but how accurate are they?
Measuring compass error

- Classic operation of “swinging the compass”
- Measure ”deviation” by comparing compass reading with series of known directions
- ”Deviation curve" shows deviation against direction (aspect)
- Not a simple linear error
  - Known since 18\textsuperscript{th} century to be harmonic curve
    - “soft iron” – period of 360°
    - “hard iron” (magnetised) – period of 180°
  - Linear offset
  - Multiple contributions
    - Including currents flowing within device!
Experimental Design

• A dozen markers placed round cricket field
• Bearings measured by compass and sextant
• Subjects sit on plastic stool
• Measure bearings to markers

The results – for “calibrated” devices
## Calibrated data

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And different apps on the same device...
Uncalibrated data

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| Mean | 26.60 | 23.50 | 19.02 |
A couple of comments

• Calibration –
  • “figure of 8” motion
    • Not a very definitive algorithm...
  • Comparison of change in compass “reading” with gyro/accelerometer
  • Can detect inconsistent rotational measurements, but not linear offsets
  • Appears not to persist...!

• Fabrication
  • No guarantee that true 3 axis compass
  • 2D compass is normal silicon fabrication
  • Third dimension *may* have different characteristics
  • May explain difference between Android and Apple (/Google)
Does it matter?

• One key use of landmarks is to define a leading line (approach vector)

• Leading (approach) line from ~D to C

• Using the approximation $\tan \theta \approx \theta \approx \sin \theta$, for $\theta$ less than about 0.1 radian

• Error in identifying front mark B due to compass error $\theta$ gives error in leading line $\phi$, where

$$\phi \approx \theta \cdot \frac{d2}{d1}$$
So – what do we need to solve?

- Want to place annotations / markers
- Limited / no possibility of registration
- Significant / unknown / varying compass errors
- Hence, markers almost certainly in wrong place

- Likely to use AR only when unfamiliar with location
  - Wrongly positioned markers could lead to major navigation errors

- This is a **real safety risk**

- How should we represent / manage the errors?
Approaching St Peter Port (CI)

- Pale blue/white – probably enough water to float
- Green – rocks – call the RNLI
- Yellow – land – call the AA

- Interested in three landmarks
- Separated by only a few degrees (from current position)
- Not a lot of scope for error
Representing the errors

• Use error bars?

• Error bars will probably overlap...
• And, in any case, error is unknown
• But – errors *are* correlated
  • The deviation is the same for each landmark for a given aspect
Representing the errors

• Connect markers using Yoke

• Nudge arrows to align one of the markers visually
  • (while holding the thing still...)
  • In which case the others will also be correct
  • But only for that aspect
Aligning the markers

• Bring the human into the equation
  • Harness remarkable ability of humans to recognise objects
  • Avoids “head-down” navigation (major concern for RNLI...)

• Display image(s) of landmark(s)
  • Where?
  • When?
  • Which?
    • Selected or automatic?
    • How respond if change aspect of device?
Pop-ups on chart?
Inset in display image?
Combine with “yoked” markers

- BT
- R
- P

Brehon Tower
212°  1.84 NM

Rouste
233°  0.77NM

Platte
242°  1.36NM
Questions to explore

• Overall format of display
  • Usability
  • Non-ambiguity
  • Robustness

• Reference images
  • Direction
  • Lighting conditions
  • Weather (visibility etc.)

• User-centred approach essential
Conclusions

• Mobile Augmented Reality offers impressive technical opportunities
• BUT has to rely on internal sensors if registration not feasible
  • Only sensors available for marine navigation – gps and compass
  • Compasses really are inaccurate
• Users need to understand better limitations intrinsic to devices
  • And developers must design apps (including navigation apps) appropriately
• Limit impact of intrinsic errors by working with users
  • not just providing on plate
• Exploit human ability to recognise objects
  • will also avoid “head-down” navigation
Thank you

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