MOBILE COMPUTING

CSE 40814/60814
Spring 2021

System Structure

explicit input

System

explicit output
Context as *Implicit* Input

**Context:**
- state of the user
- state of the physical environment
- state of the computing system
- history of user-computer interaction
- ...

**What is Context?**
Examples of Context

- Identity (user, others, objects)
- Location
- Date/Time
- Environment
- Emotional state
- Focus of attention
- Orientation
- User preferences
- Calendar (events)
- Browsing history
- Behavioral patterns
- Relationships (phonebook, call history)
- … the elements of the user’s environment that the computer knows about…

Relevance of Context Information

- Trying to arrange lunch meeting
- Going to a job interview
- Going home after work and making evening plans
- Shopping
- Tourist
- …
Examples

- Smartphone adjusts the screen to the orientation of the device
- Apple Watch turns on display if arm lifted/rotated
- Orientation is determined by using both a gyroscope and an accelerometer.

Examples

- Phone display adjusts the brightness of the display based on the surrounding area
- Uses a light sensor
Examples

• Device displays user’s location, shows route to a desired destination, find nearby stores, geotag images on social media, etc.
• Uses location sensor

Examples

• The time is displayed on the phone.
  • Time zone change
  • Daylight savings time
Examples

• Device disables touch screen when the user speaks on the phone
• Uses a proximity sensor (infrared signal travel time)

Examples

• **Active Badge** location system
  • One of the first context-aware applications
  • **Context = location**
• Call-forwarding system
• Issues
  • Private call forwarding to a public room
  • Call is forwarded to important meeting
Examples

• Schneider trucking trackers
  • Uses GPS to track loads
  • Sends a notification when a load nears its destination
  • Sends emergency notifications when certain conditions are met

Why Use Context?

• **Reduce cognitive load of user**
• **Proactivity**
  • Set up environment according to user’s preferences/history
  • Auto-completion of forms (location, time in timetable)
  • Reminders
• **Search and filter information** according to user’s needs
• **Avoid interrupting** the user in inappropriate situations
• **Smart environments**
  • Turn devices on/off, start applications, … depending on location, time, situation (lecture, meeting, home cinema, …)
  • Discover and use nearby interaction devices
Definitions of Context

• “Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves” [Dey et al. 2001]

• **Auxiliary**: not essential
• **Relevant**: can actually be used

Classification I

• **Time** Context (current time, day of week, etc.)
• **Physical** Context (location, temperature, pollution levels, noise levels, etc.)
• **User** Context (characteristics, habits, history, etc.)
• **Computational** Context (user input, customer history from database, network status, etc.)
Classification II

- **External (physical)**
  - Context that can be measured by hardware sensors
  - Examples: location, light, sound, movement, touch, temperature, air pressure, etc.

- **Internal (logical)**
  - Mostly specified by the user or captured monitoring the user’s interaction
  - Examples: the user’s goal, tasks, work context, business processes, the user’s emotional state, etc.

Challenges

- **Self-Awareness:**
  - Context-awareness helps technology to “get it right”
  - But context is hard to sense (quantity, subtleness)
  - Computers are not self-aware like humans

- When the system does the wrong thing
  - auto-locking car doors
  - screen saver during presentation
  - microphone amplifying a whisper
Challenges

• Intelligence
  • Context data must be coupled with the ability to interpret it, but computers are bad at “common sense”.
  • More rules ≠ intelligence
  • More rules = more complexity, harder to understand

• Keep “Human in the Loop”?
  • computers can detect, aggregate, portray information
  • allow human users to interpret and act on it
  • is this a good strategy for all context-aware systems?

Challenges

• Programming:
  • Developers have little experience with devices that gather the data (e.g., gyroscopes).
  • Data gathered from a sensor must be interpreted correctly in order for it to be useful.
  • Context comes from various sources and in order for this data to be useful it must be combined correctly (i.e., the gyroscope and accelerometer working together to determine orientation).
  • The context changes constantly in real time.
Challenges

- **Usability vs. control?**
  - Automation reduces the amount of work that users have to do
  - Users like the idea of a device that completes tasks on their behalf
  - However, when users use these devices they feel a **loss of control** if a device has a high level of automation

Challenges

- **Privacy**
  - Should law enforcement be able to access the history of a user?

- **Correctness**
  - Errors fusing data
  - Detection errors
  - Interpretation errors

- **Complexity**
  - Difficult to develop, maintain, understand
  - Reduces accuracy of the application
Challenges

- **User preferences**
  - May not match what the device does!
  - Everyone is different!
    - What is your idea of “nighttime”?
    - What is your idea of “warm”? Or “loud”?

- **Information overload**
  - Can overwhelm the user

Solutions

- Keep an appropriate level of automation (avoid uncertainty)
  - The more automation we have, the less control we have over what is happening.
  - What happens if we give all control to machines?
  - Would you trust your phone to give you a dose of medicine?
  - Keep a balance between uncertainty and automation.
Solutions

- Avoid unnecessary interruptions
  - Phone flashes a notification every 30 seconds
  - Eventually the user will ignore it!
- Avoid information overload
  - Too much information can overwhelm the user, and bog down the device
  - Example: Walking down a busy street a user’s device is bombarded with suggestions of places to shop
## Solutions

- Keep an appropriate level of system status visibility
  - Allow the user to see what action the device is taking
  - Be sure the user understands *why* the device is performing the action
- Account for the impact of Social Context
  - A loud alert is not ideal for all situations
- Allow for the personalization of individual needs
  - Allow user to change location names (set a location name to "home" for example)

## Solutions

- Secure the user’s privacy
  - Selling information to advertisers…is this right?
  - Giving information to the police, when does this cross the line?
  - Sharing context information with others—Facebook location