A Toolkit for Managing User Attention in Peripheral Displays

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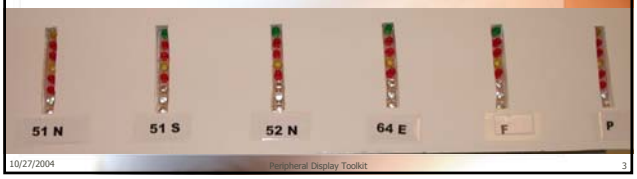
Problematic Scenario

- Bus schedule
  - Requires a task switch to use
  - Doesn't afford continuous monitoring

RTE NUM	LAWR HALL	GRIZ SR.	EUCL GRIZ	CNTR SHAT
65	605a		616a	630a
65	635a		646a	700a
65		703a	716a	730a
65	735a		746a	800a
65		803a	816a	830a
65	835a		846a	900a
65		903a	916a	930a
65	935a		946a	1000a
65		1003a	1016a	1030a
65	1035a		1046a	1100a
65		1103a	1116a	1130a
65	1135a		1146a	1200p
65		1203p	1216p	1230p
65	1235p		1246p	100p
65		103p	116p	130p
65	135p		146p	200p
65		203p	216p	230p
65	235p		246p	300p
65		303p	316p	330p
65	335p		346p	400p

Solution: Peripheral Displays

- Provide awareness with min attention
- Separate from primary task
- Bus LED Display
  - + Get bus info at a glance
  - + Dynamically manages attention it attracts
  - – Hard to accomplish



Why is creating PDs hard?

- Need to ***abstract*** info to be glance-able
- Need mechanisms for dynamically managing attention PDs attract:
  - Deciding attention levels to attract (***notification levels***)
  - Displaying info appropriately (***transitions***)
- Our contribution:
  - Peripheral Display Toolkit (PTK) supports these key issues in PD creation

Example PTK Applications

- Remote Activity
  - Social Guitar
  - Audio Monitor
  - Motion Monitor
  - Remote Awareness Display
- Bus Displays
  - Bus Mobile
  - Bus LED
- Instant Messenger Status

Orb showing remote activity

Social Guitar

IM Picture Frame

Bus LED

BusMobile

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BusMobile

Example PTK Applications

+ Manage attention with abstraction, notification levels, & transitions
+ Glance-able
+ Few lines of code
+ Simplified code design & code re-use

Orb showing remote activity

Social Guitar

IM Picture Frame

Bus LED

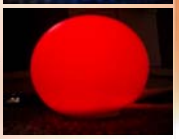
BusMobile

Simple Example: Motion Monitor

no/low motion →

medium motion →

high motion →

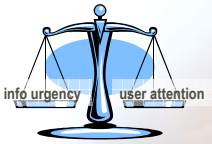


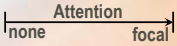
Outline

- PTK: Motivation & Examples
- Managing attention
  - Abstraction
  - Notification levels
  - Transitions
- Toolkit Architecture & Library
- Conclusion

Managing User Attention

- Attention is a crucial issue in design
  - Significant impact on success
  - More info can be monitored w/o overburdening
- Attention management is difficult
  - Used to designing apps that attract full attention
  - Attention attracted should match info urgency



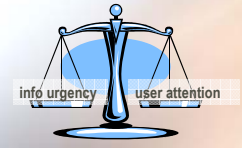


- Literature surveys led to key characteristics of attention management

Attention Management Characteristics

From survey of peripheral displays:

1. Abstraction
   - enables lower-attention info consumption
2. Notification levels
   - help determine how much attention to attract based on urgency of info
3. Transitions
   - enable display of info to match urgency



Abstraction

- Enables lower-attention consumption of info
- Extracting features or reducing fidelity of info
- Motion Monitor: replaces video images with general motion amount (high, medium, none)

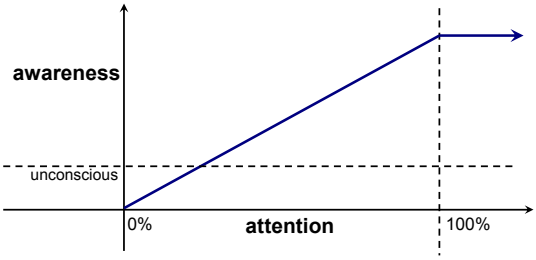
video images → abstraction → amount of motion

- high motion
- medium motion
- no/low motion

Notification Levels

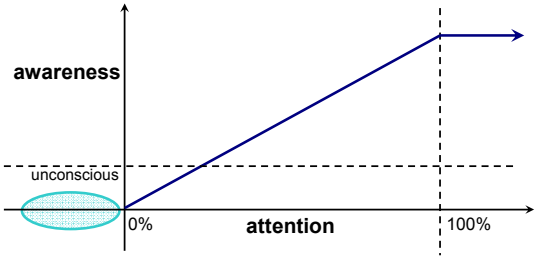
- Indicate the urgency of info
  - Low levels = non-urgent info
  - High levels = more urgent info
- Motion Monitor: doesn't show urgent info, so uses low notification levels

More on Notification Levels



- Attention is (roughly) scalar – PD designers must decide where on the scale displayed info should fall

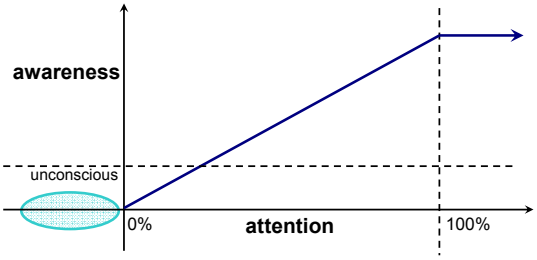
More on Notification Levels



Attention Type

1. None

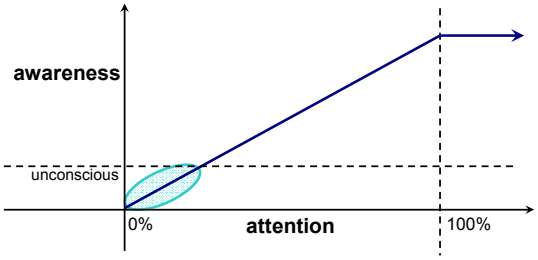
More on Notification Levels



Attention Type → **Notification Level**

1. None → Ignore

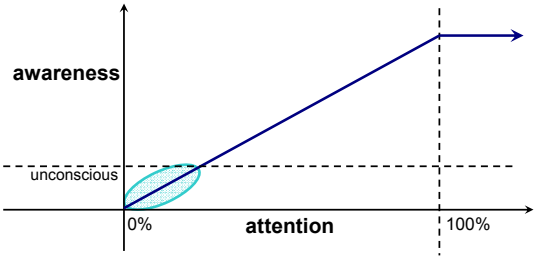
More on Notification Levels



Attention Type → **Notification Level**

1. None → Ignore
2. Inattention

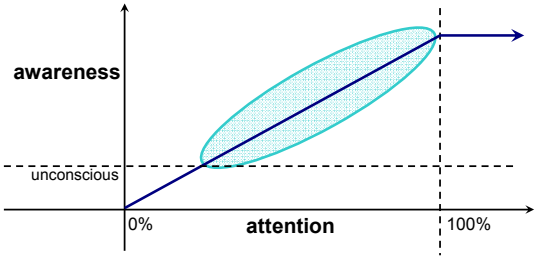
More on Notification Levels



Attention Type → **Notification Level**

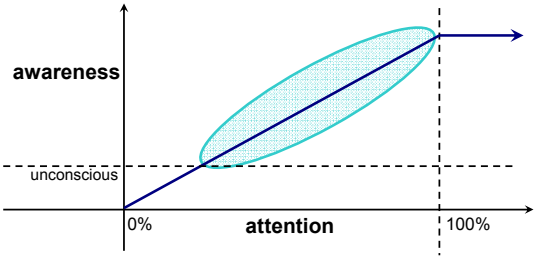
1. None → Ignore
2. Inattention → Change blind

More on Notification Levels



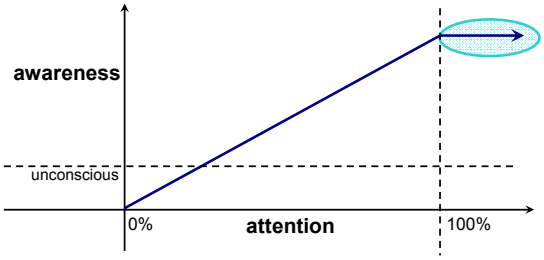
Attention Type		Notification Level
1. None	→	Ignore
2. Inattention	→	Change blind
3. Divided		

More on Notification Levels



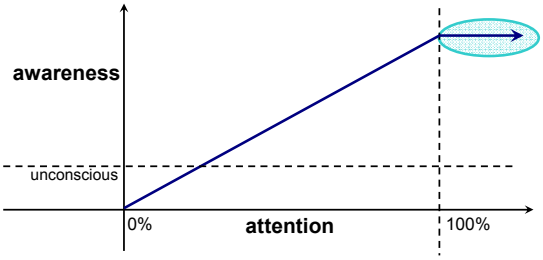
Attention Type		Notification Level
1. None	→	Ignore
2. Inattention	→	Change blind
3. Divided	→	Make aware

More on Notification Levels



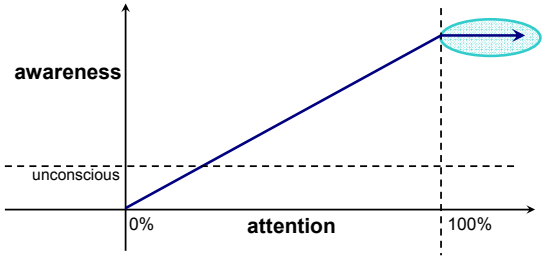
Attention Type		Notification Level
1. None	→	Ignore
2. Inattention	→	Change blind
3. Divided	→	Make aware
4. Focused		

More on Notification Levels



Attention Type		Notification Level
1. None	→	Ignore
2. Inattention	→	Change blind
3. Divided	→	Make aware
4. Focused	→	Interrupt

More on Notification Levels



Attention Type		Notification Level
1. None	→	Ignore
2. Inattention	→	Change blind
3. Divided	→	Make aware
4. Focused	→	Interrupt
5. Focused + interaction	→	Demand action

Transitions

- Enable display of info to match urgency
- Depend on notification level
  - Ignore: no changes
  - Change blind: fading, slow motion, tiny updates
  - Make aware: discrete, abrupt updates
  - Interrupt: flashing, beeping, vibration
  - Demand action: interrupt until user does action
- Motion Monitor: varies pulse speeds for different notification levels

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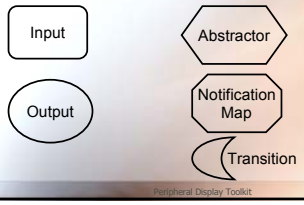
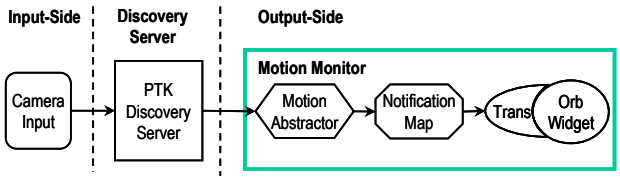
PTK Architecture

1. Support for managing impact on human attention using abstraction, notification levels, and transitions
2. Simplified code design and code re-use
3. Library of common PD components



Motion Monitor Architecture



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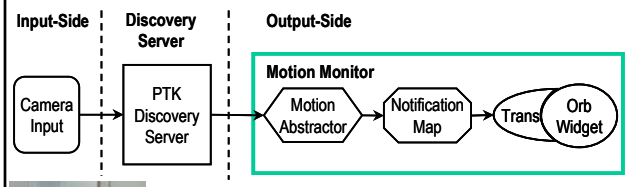

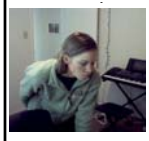

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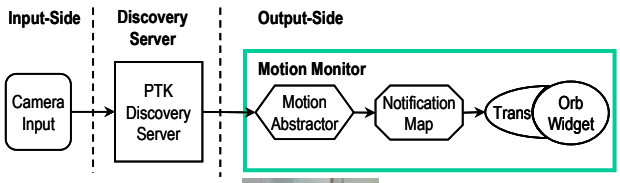
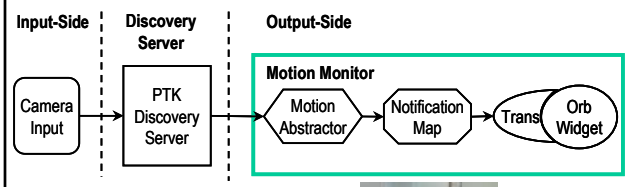
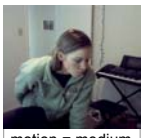


motion = medium

Motion Monitor Architecture

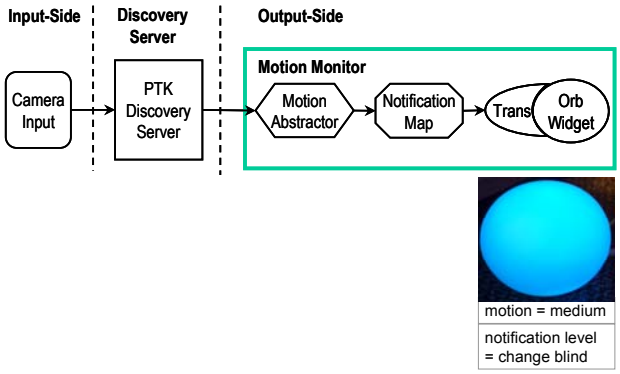




motion = medium

notification level = change blind

Motion Monitor Architecture



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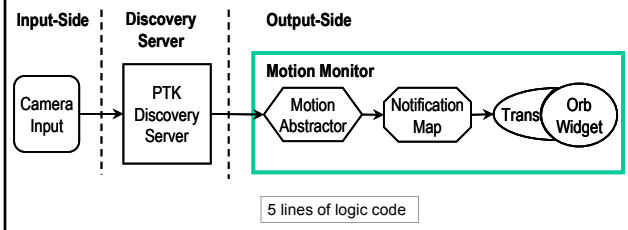
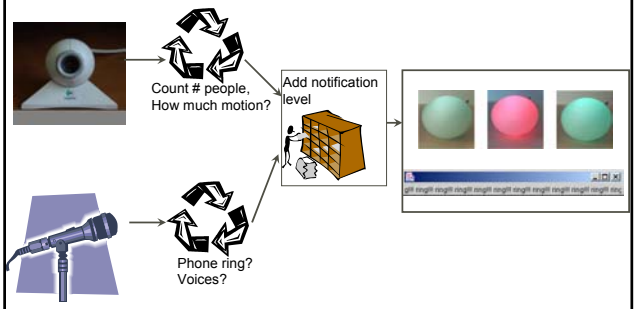
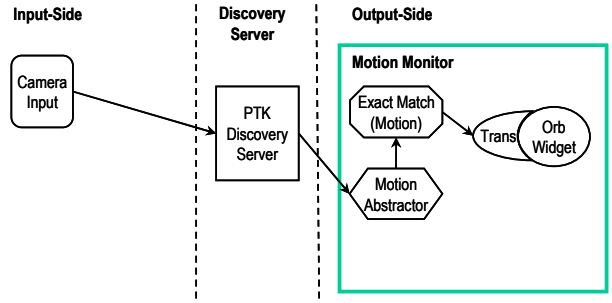


Remote Awareness Display



Motion Monitor → Remote Awareness Display



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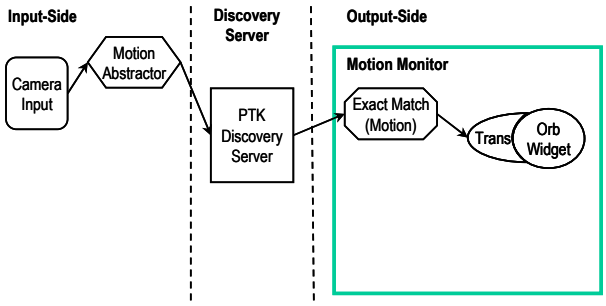

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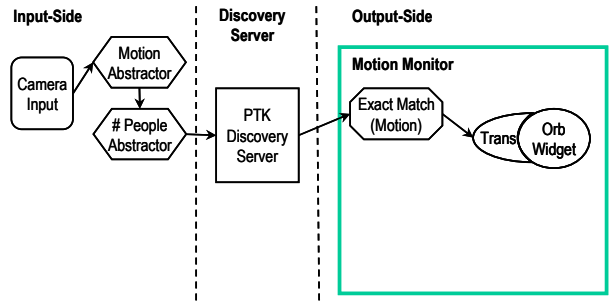

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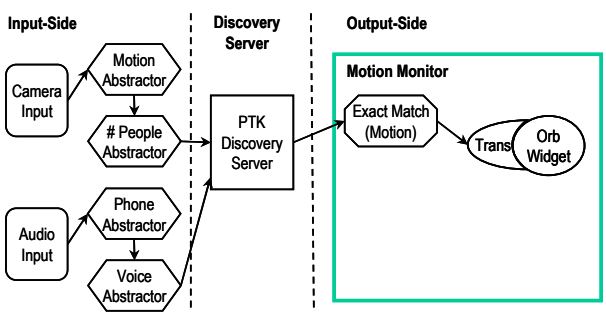

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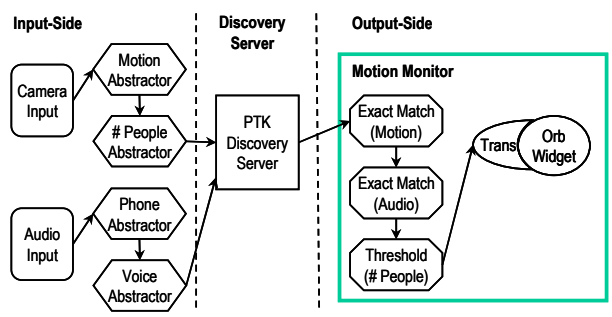

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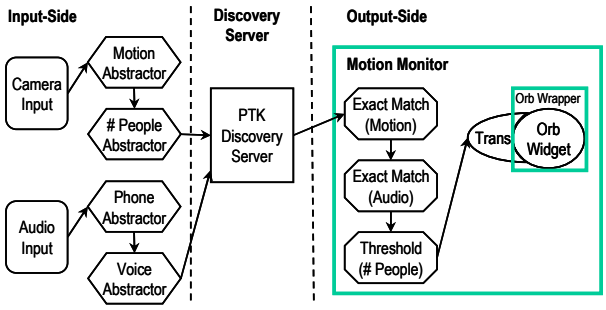

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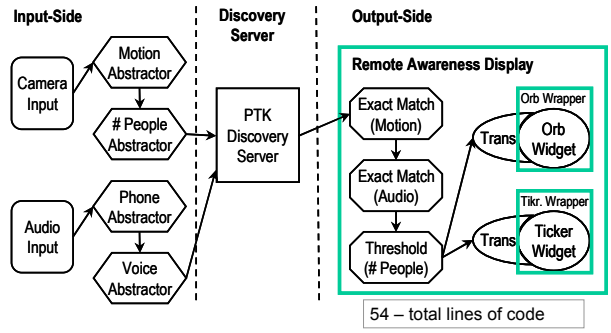
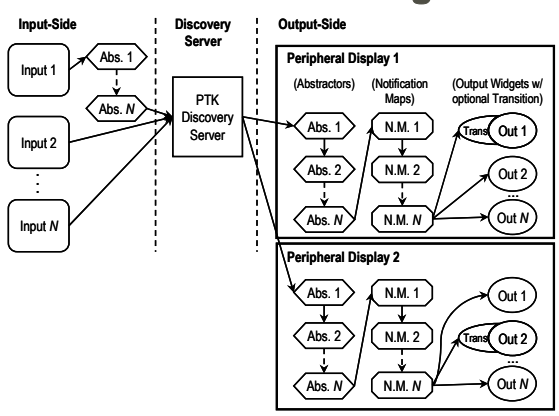


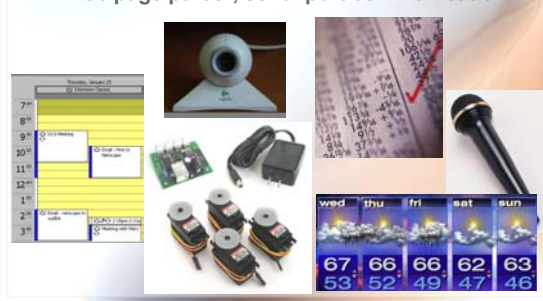
54 – total lines of code

General Architecture Diagram



Library Components

- Input
  - audio, camera, Phidgets, Context Toolkit, online calendars, news, stocks, weather, Web page parser, serial port communication



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- Output
  - ticker text, Ambient Orb, Phidgets
- Abstractors
  - motion, people counting, voices, phone ringing
- Notification
  - exact match, threshold, contains, degree of change

Transitions

- PTK provides architectural support for implementing as animations
  - Timing
  - Number of steps
  - Flashing (single, repeated)
- Tied to output
  - Depend on output modality
  - Example transitions: color changing and pulsing (orb); fading, motion, & flashing (ticker text)

Future Work & Conclusion

- PTK supports the creation of PDs
- Focuses on managing user attention
- To do this, uses abstraction, notification levels, transitions
- Validated with 7 example applications
  - Supports attention management
  - Facilitates code re-use
- Future work
  - Incorporate interruptibility and local context sensing
  - Cross-modality animations
  - PD evaluation support

Questions?

- For more information & downloads:

  www.cs.berkeley.edu/projects/io/ptk/

  tmatthew@cs.berkeley.edu

Thanks to…

NSF, Ed De Guzman, Jeff Heer, Scott Klemmer, Berkeley & CMU

What about user context?

- PDs must 2 sets of attention issues:
  - User context
    - interruptibility, primary activity, focus of attention
  - Attention management
    - balancing info urgency and user attention
- PTK focuses on attention management
  - User context invasive to sense, not practical to assume PDs have access
  - Management issues are independent of user context
- Context input can be considered on a library level (in notification maps)

Related Work

- **AROMA:** architectural support for abstraction
- **Context Toolkit:** infrastructure for context input and some abstraction
- **Phidgets:** library of hardware widgets for input and output
- **Real World Interfaces Toolkit:** library of X10 output widgets
- **iStuff:** infrastructure for distributed inputs and outputs