THE OHIO STATE UNIVERSITY

Transformer: A Database-Driven Approach to Generating Forms for Constrained Interaction

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Motivation

- Forms are a common interface for data-entry and querying
  - Ordering food
  - Making appointments
  - Applications
  - Doctor’s office

- Shift from paper to digital

- Smaller screens

Constrained Interaction

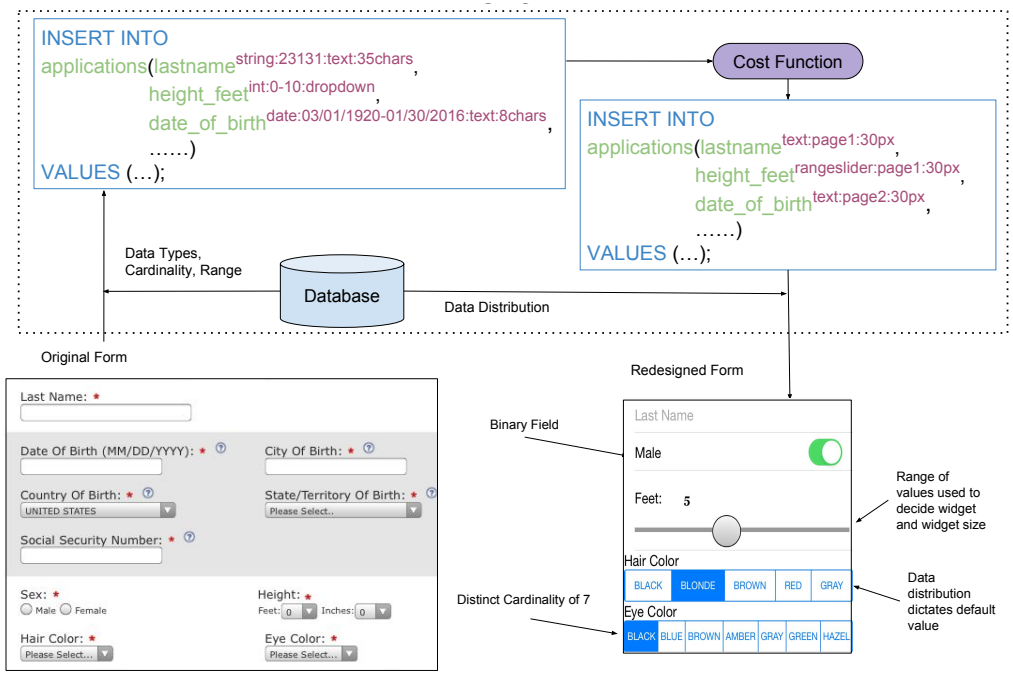
- Different devices have different ideal form layouts
- Desktops – Typing is fast
- Touch devices
  - Tablets: imprecision due to lack of physical keyboard
  - Smartphones: small screen
- Incomplete responses and errors, increase user input time

Prior Work

- Manually optimizing forms for every interface can be taxing on the form designer
  - Designers prefer aesthetics to efficiency (Sears, 1995)
- Adaptive form generation – customized to individual user's ability
- Require interaction data which is not always available
- But every form feeds a database!

Transformer

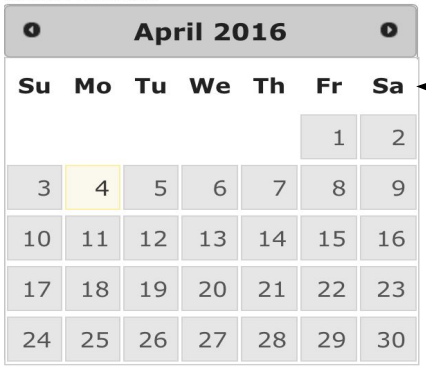
- Every form field corresponds to a database column
- Leverage prior input data estimate user effort
- Select form layout that minimizes user's data entry effort



Optimize Form Layout

Given a form (and its database), and display dimensions of output device, find the ideal data entry widget for each form field.

Datepicker

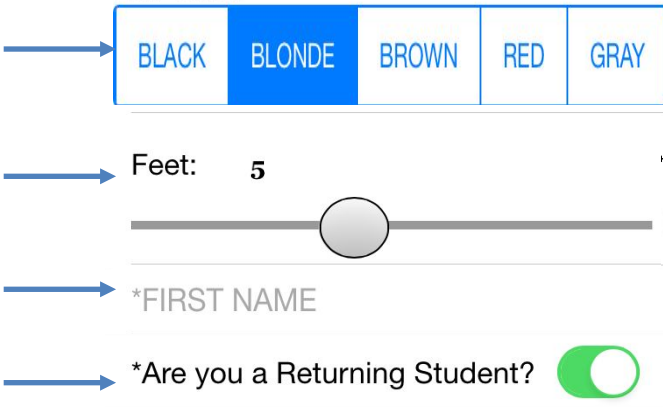


Segmented controller

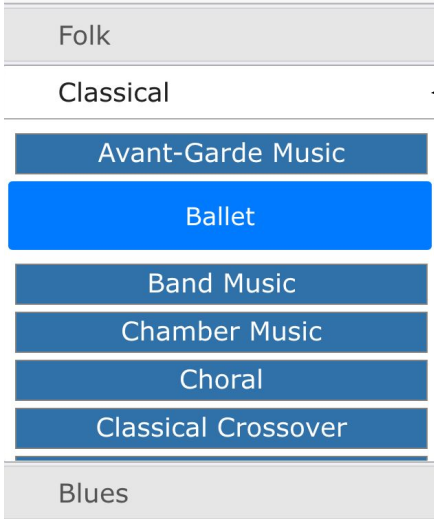
Rangeslider

Text

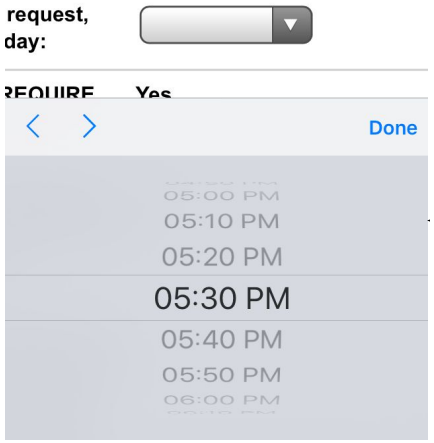
Toggle



Radio button/ Checkbox



Dropdown



Cost Model of Human Effort

- Adaptation of the GOMS Keystroke-level Model (KLM)

- Weighted Sum of 4 Interactions: Tapping, Scrolling, Sliding, Typing

$$no.of\ taps \times w_{tap} + slider\ range \times w_{slide} + no.of\ scrolls \times w_{scroll} + \text{length of word} \times w_{type}$$

Leverage Database

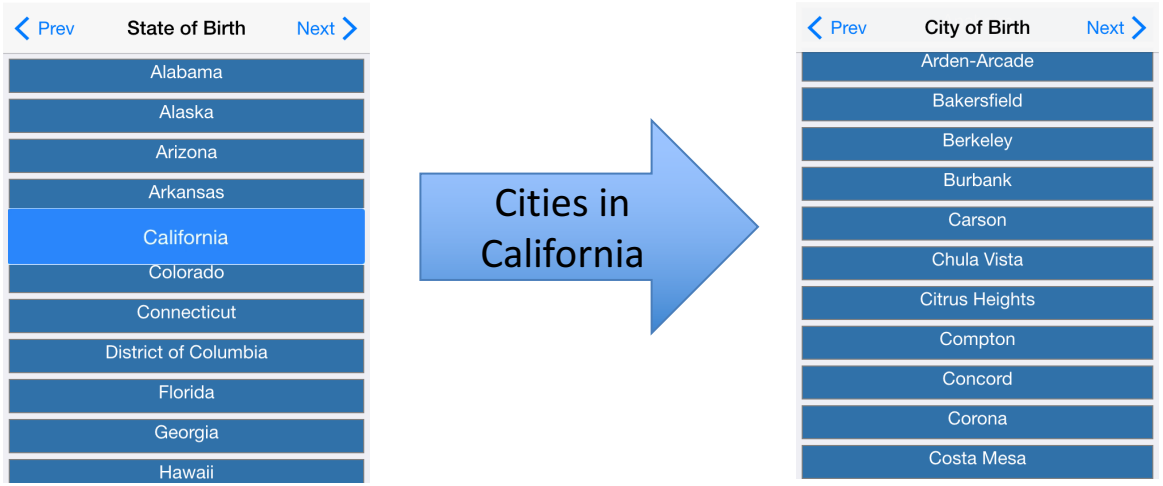
Leverage Database for Layout Optimizations and Constraints

- Schema based optimizations
  - Referential Integrity
- Datatype based constraints
- Cardinality based optimizations
  - Number of distinct items in a column

Schema Based Optimizations

- One-to-one relationship
  - only one needs to be entered, other can be inferred
    - e.g. Zip code implies City

- One-to-many relationship
  - Can be used to eliminate values of second attribute
    - e.g. Entering State constrains the Cities

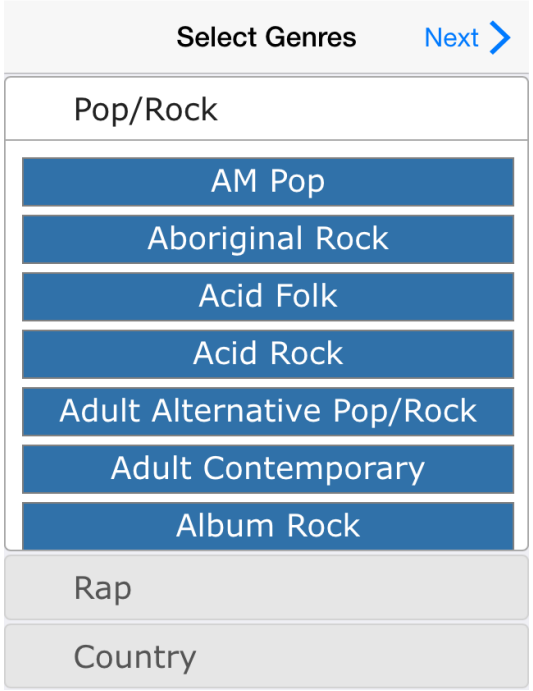


Datatype and Cardinality Constraints

- Range sliders and datepickers are only valid for numeric and date datatypes

- Segmented controller only used when all options fit on one line

- Checkboxes: binary fields grouped by foreign-key



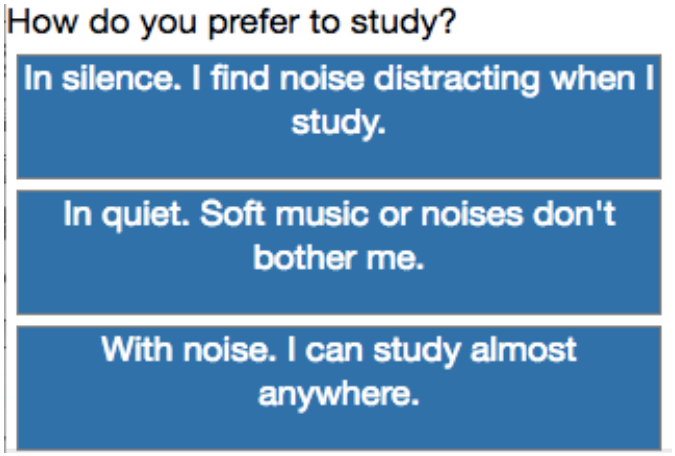
Database-Driven Cost Estimation

Widget	Cost
Radio	$\frac{count}{display} \times w_{scroll} + w_{tap}$
Dropdown	$\frac{count}{display} \times w_{scroll} + 2 \times w_{tap}$
Range slider	$(\max - \min) \times w_{slide}$
Segmented Controller	w_{tap}
Text	$avg\ length \times w_{type}$

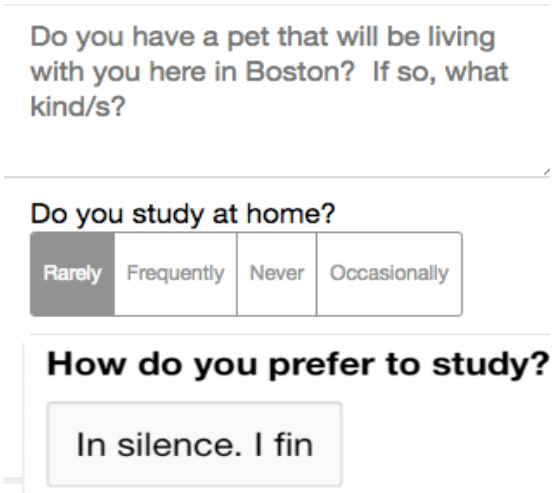
Grouping Fields

- Pagination vs. Scrolling
- Cost of widget-field combination depends on available page height
- Bottom-up approach: Add each field to page that has minimum cost widget

Whole page

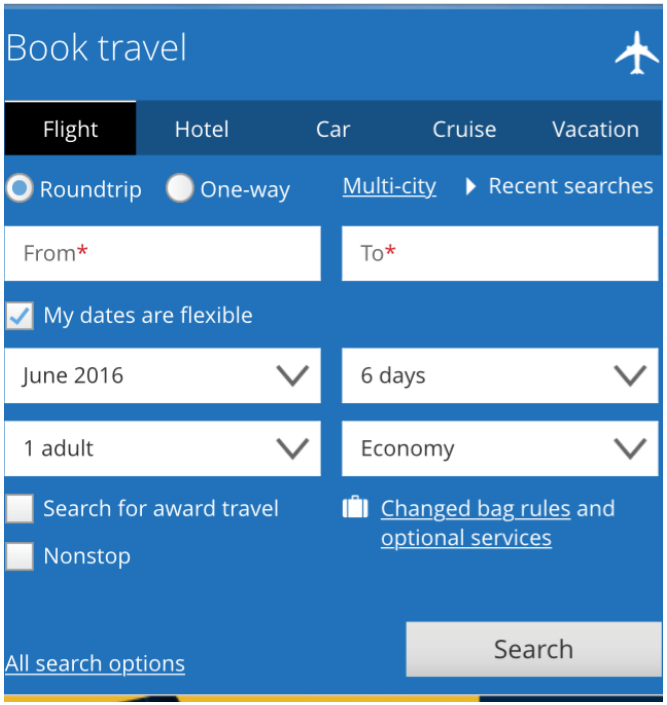


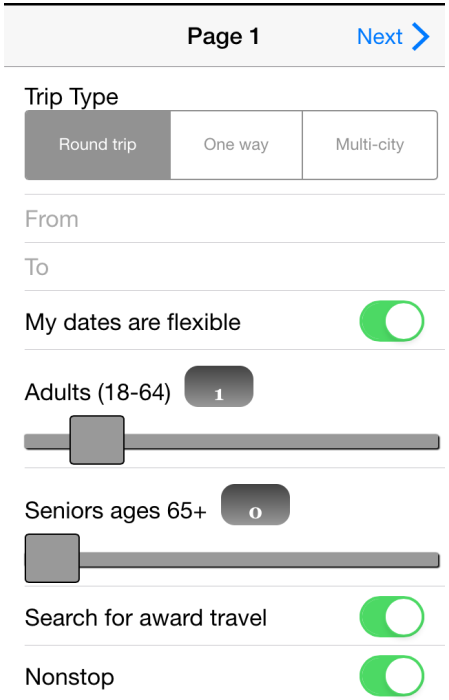
Other fields on page



Algorithm

- For each attribute:
  - For each page:
    - Find minimum cost widget
  - Add attribute to page with minimum cost widget





Evaluation

- Form Completion Time
- Error Rate
- User Rating

Dataset

- 8 Web forms
- Synthetically generated data (from database of names, countries, cities, etc.)

Form	Name	Text	Date	Dropdown	Buttons
A	Hilton Reservation	1	1	2	1
B	United Airlines	2		3	2
C	Library Search	1		5	37
D	Music Search	1		2	2
E	Roommate Matcher	5		8	10
F	Maintenance Request	4		2	5
G	Passport Application	9		6	1
H	Room Reservation	4	2	5	4

Devices and Weights

- iPhone 5s – iOS 9.3.1

- 2 device size configurations
  - Smartphone screen size - *1136px by 640px*
  - Simulated watch screen size - *300px by 300px - (*no text input)

- Weights
  - Based on prior literature – details in paper
  - Validated with pilot study of 15 users

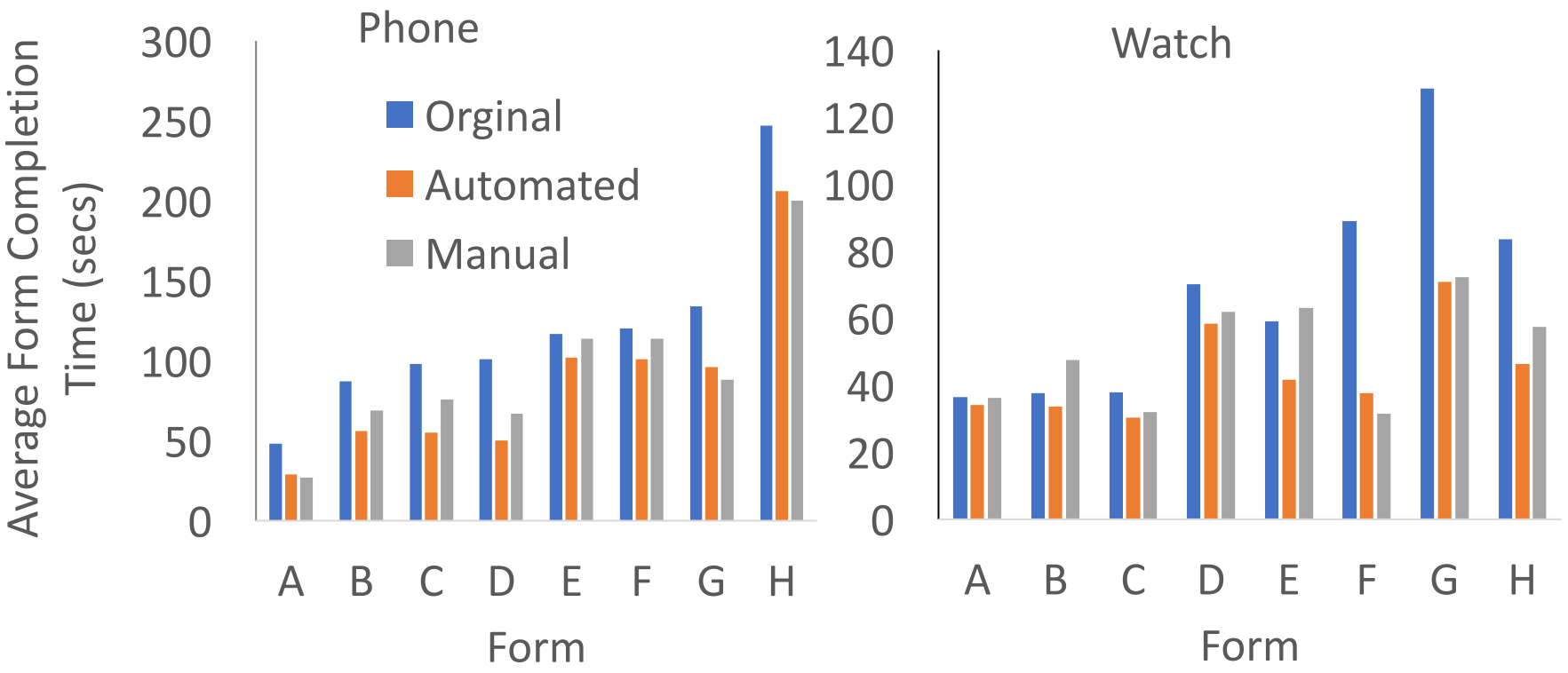
User Study Setup

- 3 versions of each form: Original, Manually Optimized and Automatically Optimized
- 30 users
  - 15 (7 male, median age 22) for smartphone
  - 15 (7 male, median age 22) for simulated watch
- Within-subject study per device configuration
  - 3 x 8 = 24 forms per user
- Order of forms randomized

User Study Procedure

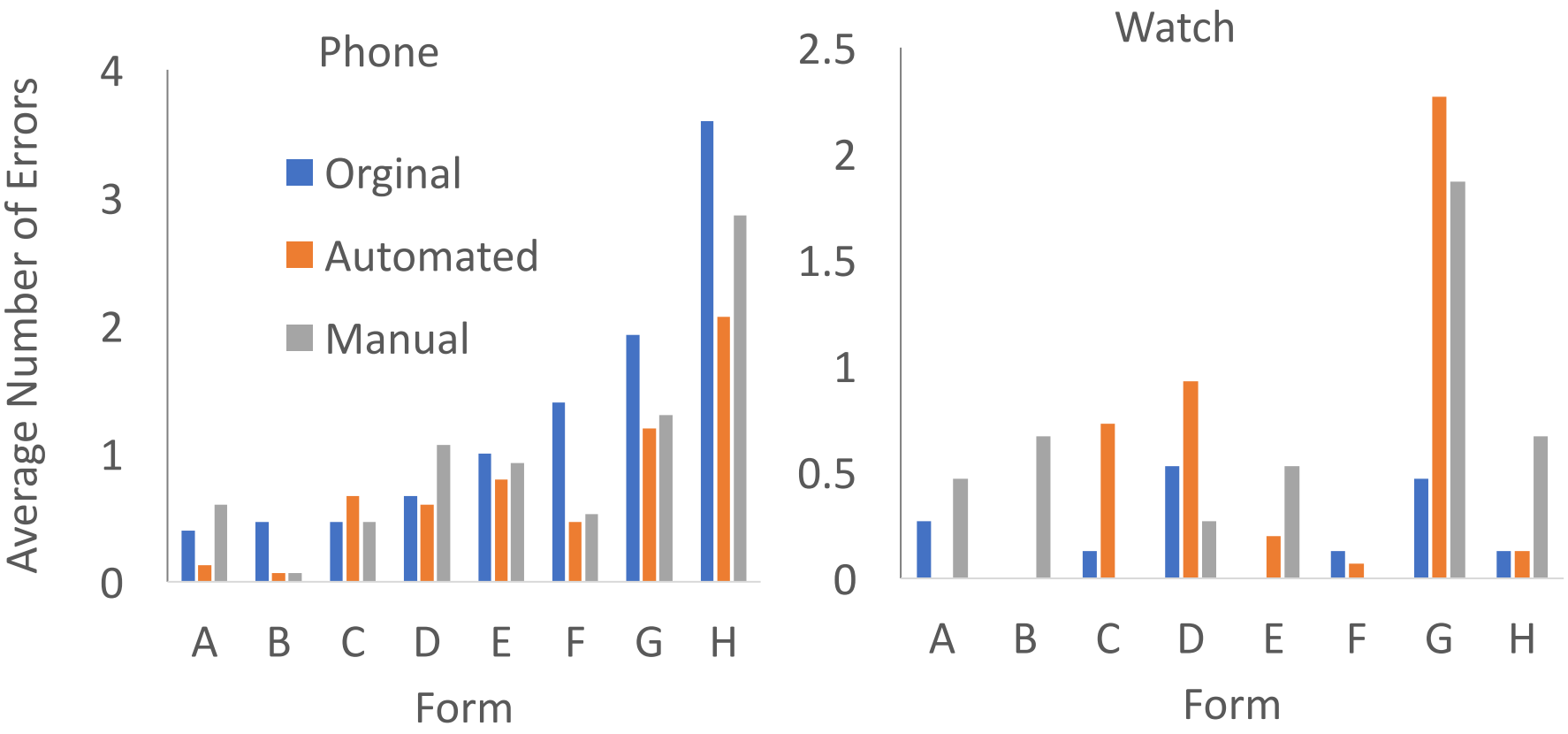
- Pre-study questionnaire on phone usage
  - No significant difference in results based on frequency of phone usage or phone type
- Presented with printed information to be filled in to control for motor memory
- Rate usability on scale of 1-10 at end of each of form

Form Completion Time



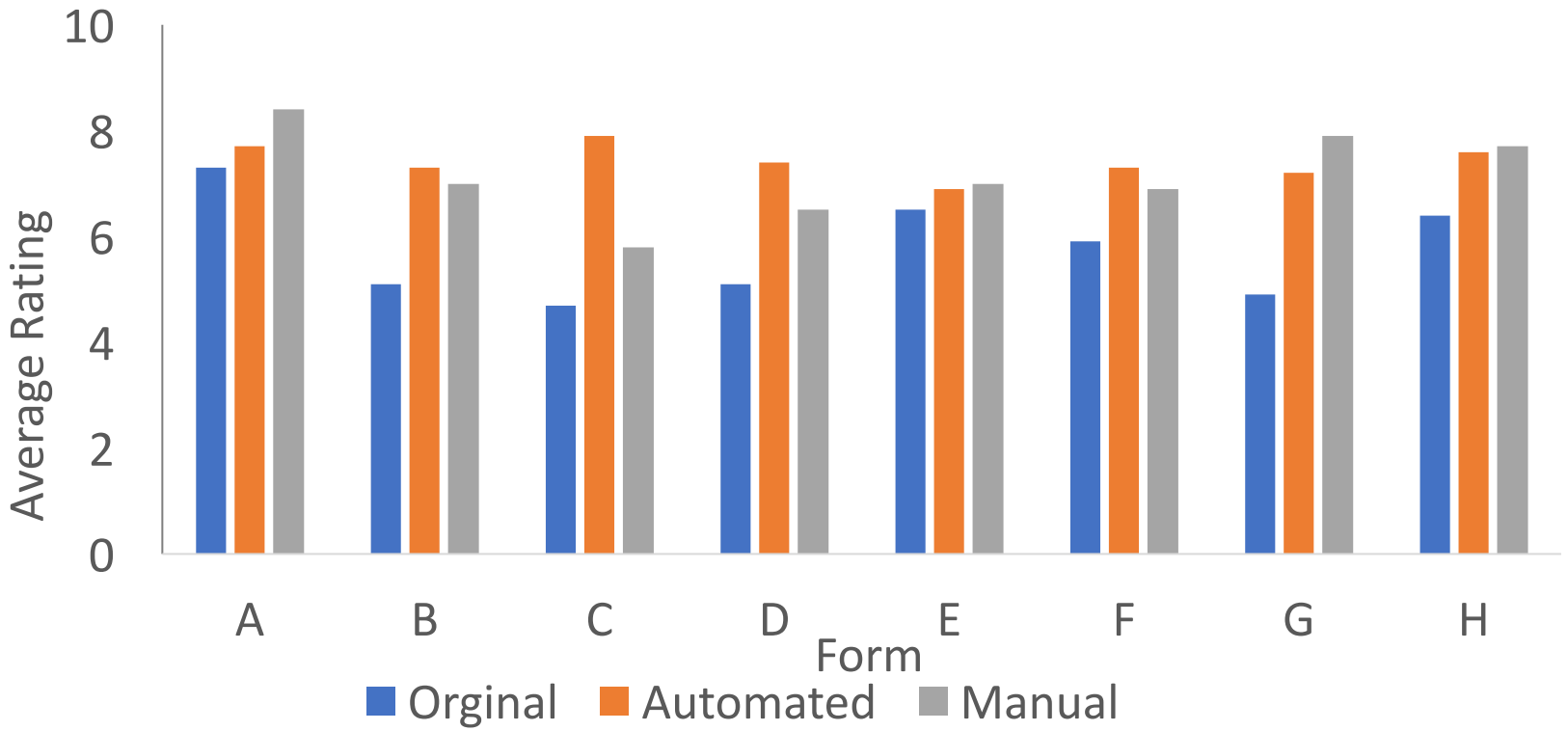
- Upto 50% reduction in form completion time between the original and automated forms

Error Rate



- Most errors stemmed from text entry on phone
- On watch, redesigned forms had errors due to accidental selection due to large widget size

User Rating - Phone



- Average Rating from 1-10 (10 indicated very usable)
- Results on simulated watch are comparable

Summary

- Different screen sizes require different form layouts
- Leverage database to model cost of human input
- Automatically generate form layout for given screen size
- Future Work
  - Semantically group fields
  - Incorporate aesthetics into cost model

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Thank you!

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amazon web services

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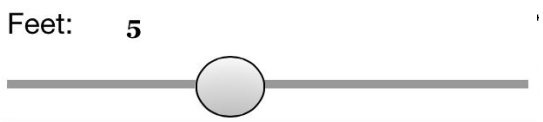
Google

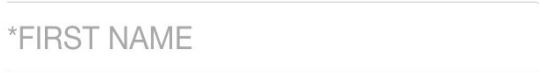
Widgets

Segmented controller

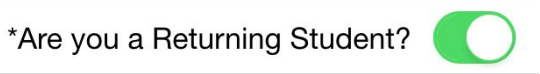
Rangeslider



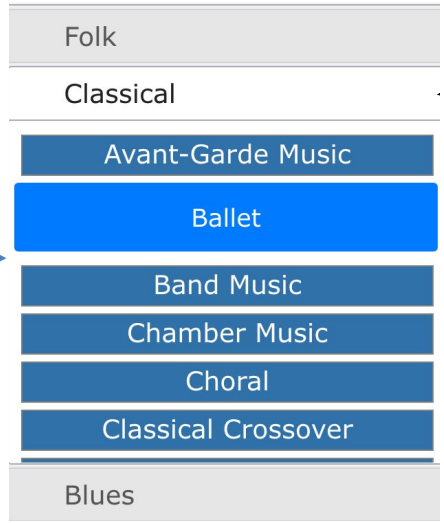
Text



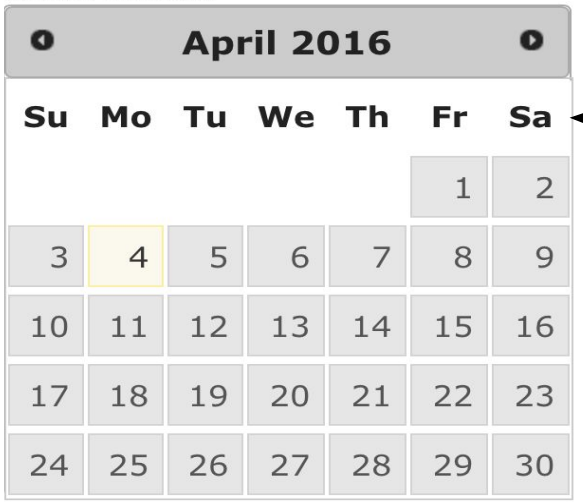
Toggle



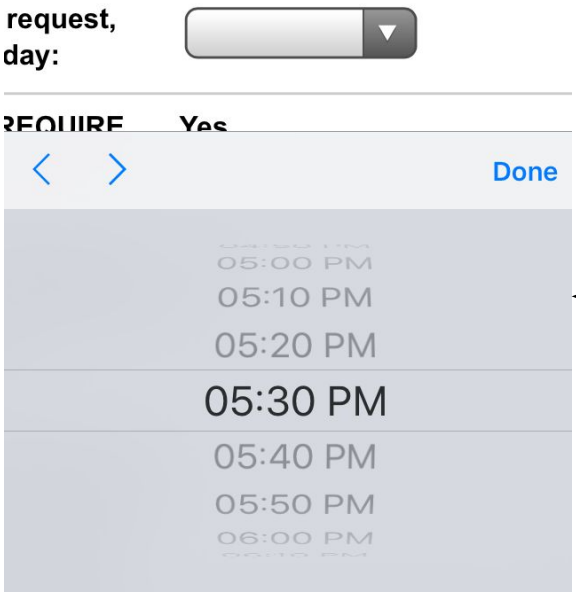
Radio button/ Checkbox



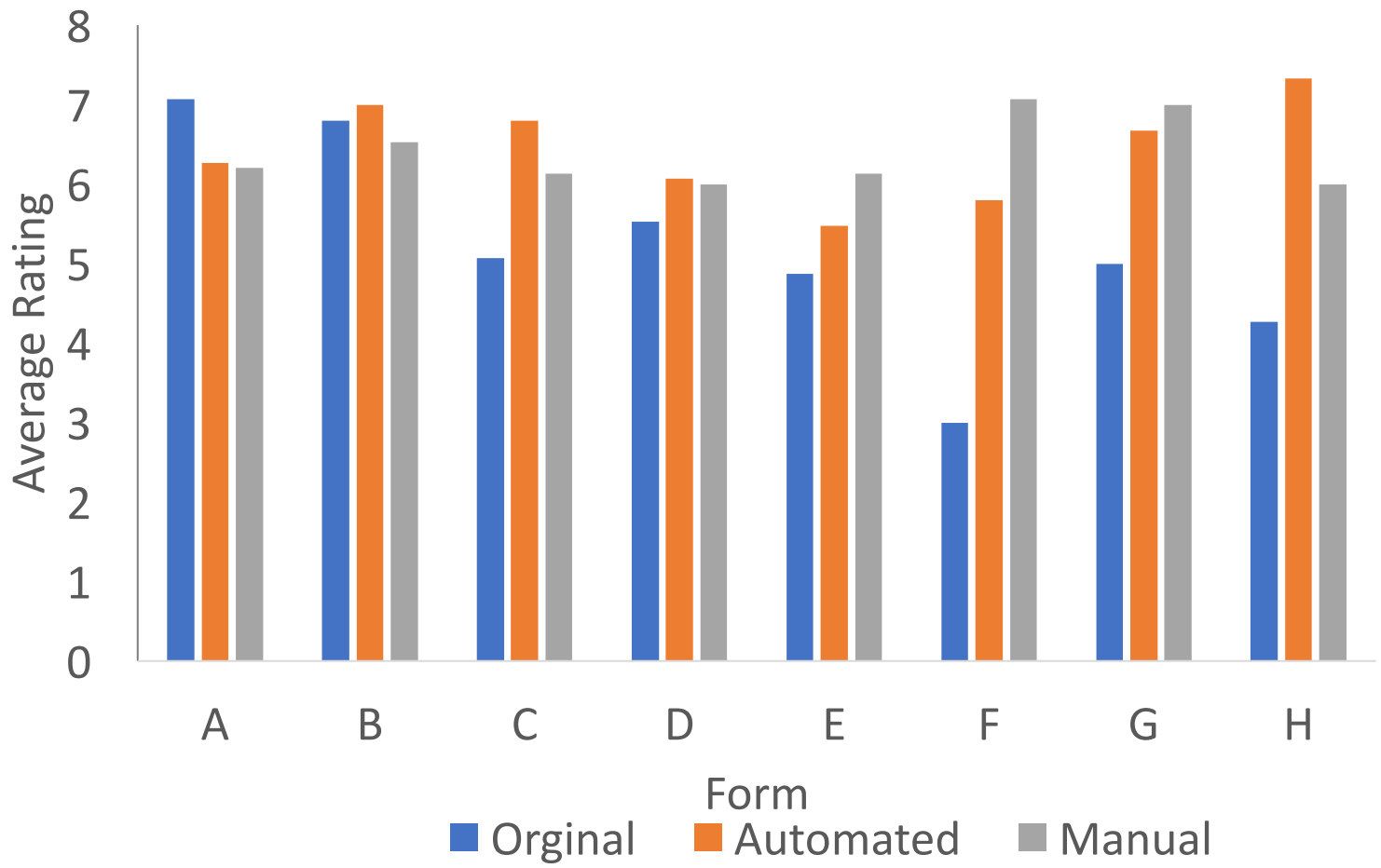
Datepicker



Dropdown



User Rating - Watch

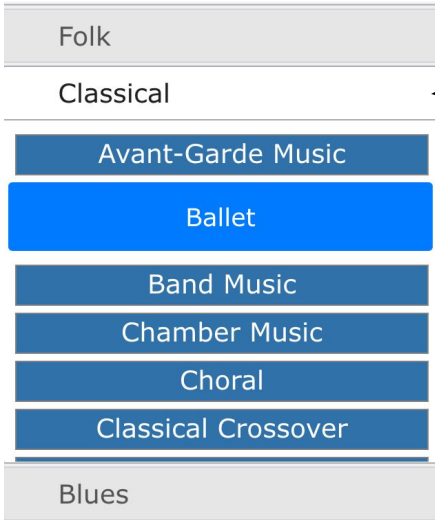


Weights

- Based on prior literature
- Validated with pilot study of 15 users

Parameter	Weights
w_{slide}	.5
w_{tap}	1
w_{scroll}	3
w_{type}	7

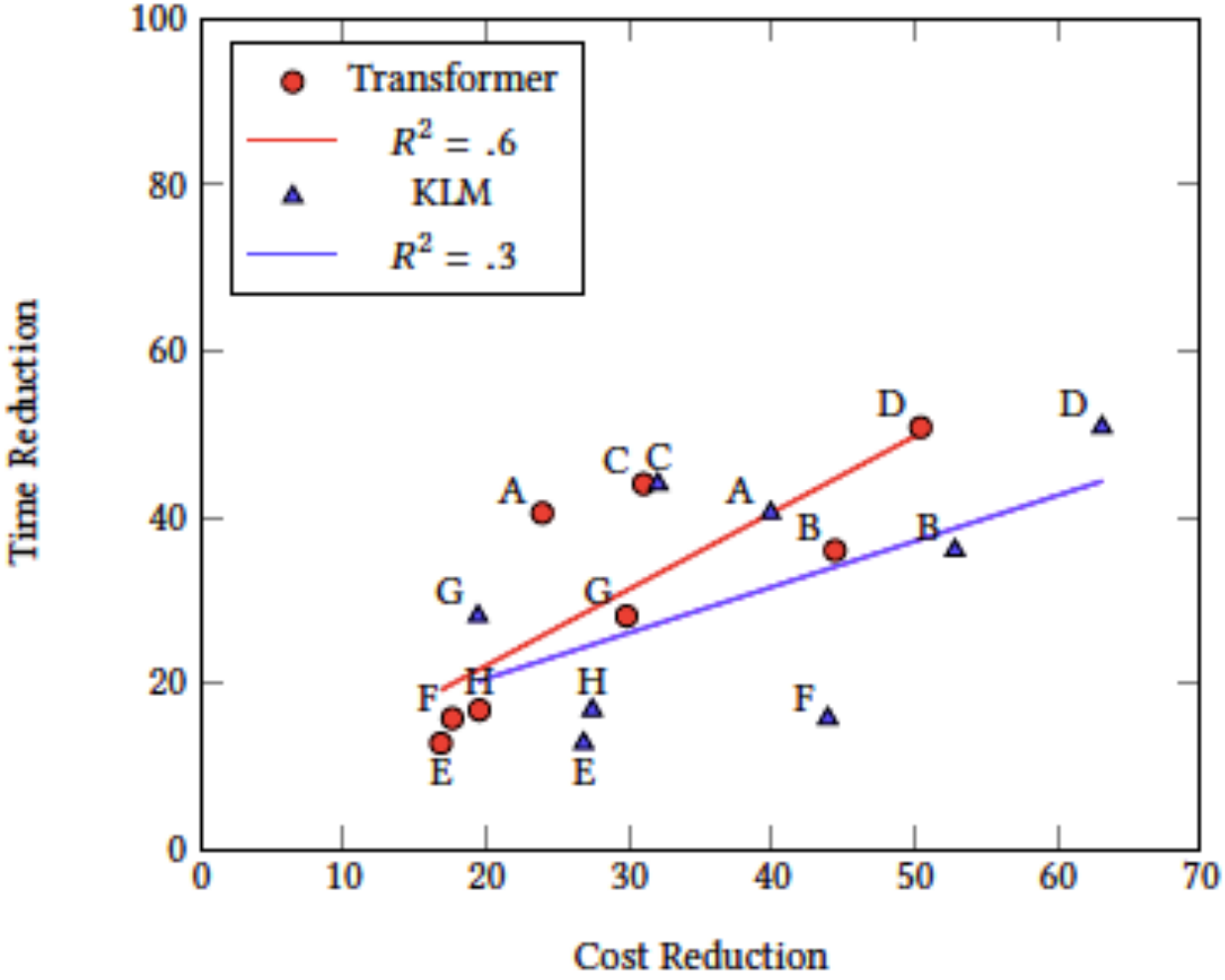
Cost Estimation per Widget



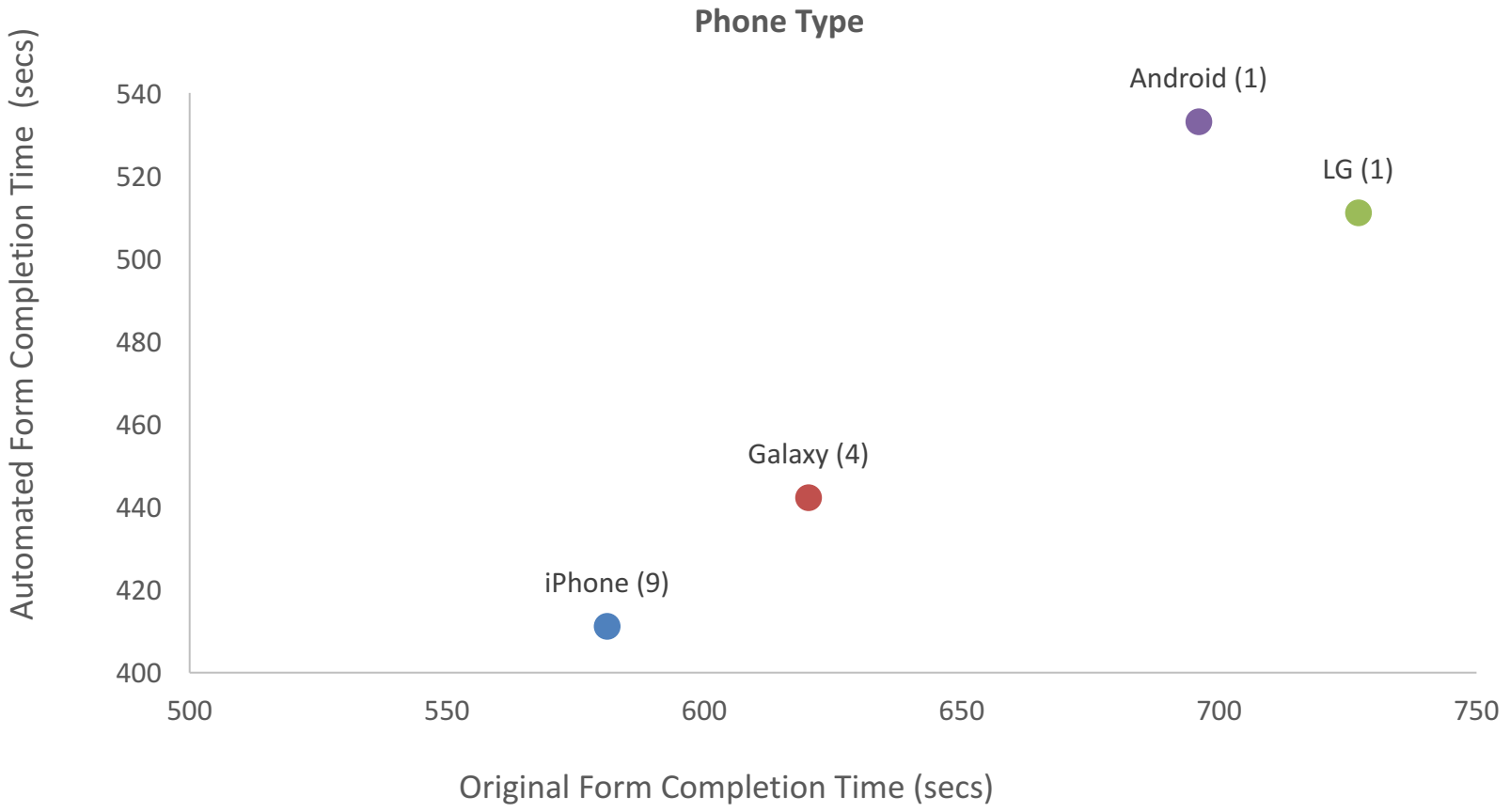
Widget	Cost
Radio	$\frac{count}{display} \times w_{scroll} + w_{tap}$
Range slider	$(max - min) \times w_{slide}$
Segmented Controller	w_{tap}
Text	$avg\ length \times w_{type}$

- Sliders can only be used for numerical fields
- Toggle and checkboxes are only compatible with binary fields

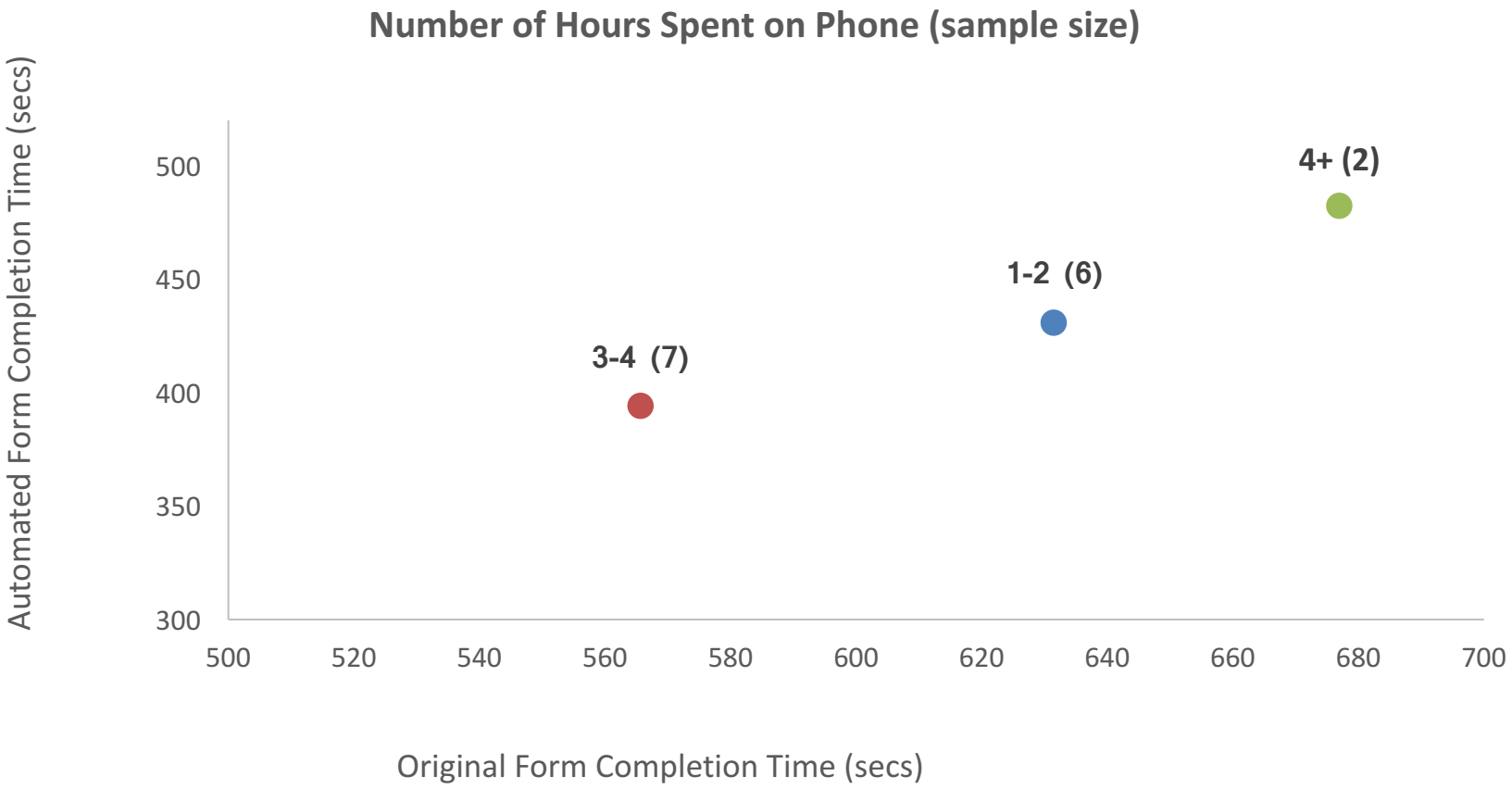
Cost Validation



Smartphone Completion Time By Phone Type



Smartphone Completion Time By Phone Type



Database-Driven Cost Estimation

Widget	Cost
Radio	$\frac{count}{display} \times w_{scroll} + w_{tap}$
Checkbox	$\frac{count}{display} \times w_{scroll} + w_{tap} \times count$
Range slider	$(\max - \min) \times w_{slide}$
Datepicker	$(count_{month} + count_{year}) \times w_{tap} + w_{tap}$
Segmented Controller	w_{tap}
Dropdown	$count \times w_{scroll} + 2 \times w_{tap}$
Toggle	w_{tap}
Text	$avg\ length \times w_{type}$