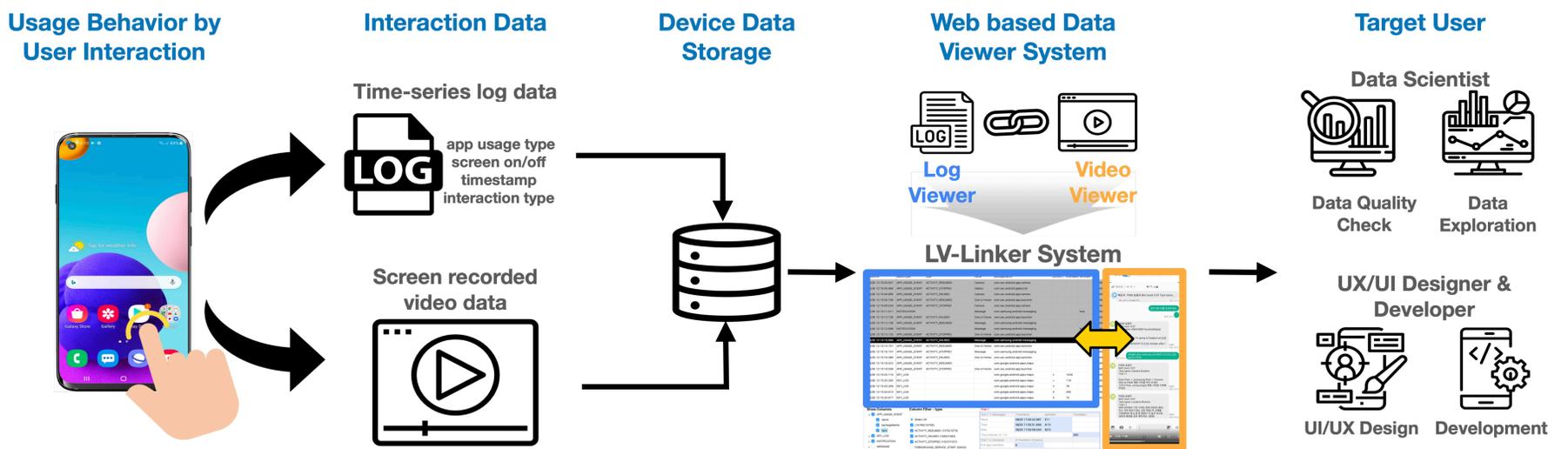# LV-Linker: Supporting Fine-grained User **Interaction Analyses** by **Linking** Smartphone **Log** and Recorded **Video** Data

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Usage Behavior by User Interaction → Interaction Data (Time-series log data: app usage type, screen on/off, timestamp, interaction type; Screen recorded video data) → Device Data Storage → Web based Data Viewer System (Log Viewer, Video Viewer — LV-Linker System) → Target User (Data Scientist: Data Quality Check, Data Exploration; UX/UI Designer & Developer: UI/UX Design, Development)

Background & Problem

- **Data-driven mobile design** for UI/UX research requires
  - Recorded **screen video** data
    - Pros: Easy to identify the user behavior patterns without learning difficulties
    - Cons: Difficult to manage the sensitive and large data
  - Time-series **usage log** data
    - Pros: Easy to perform data preprocess & analysis and remove sensitive data for privacy issues and small volume
    - Cons: Steep learning curve

- In current mobile data-driven UI/UX research, there is a **lack** of interactive **tools** that support **simultaneously navigation** of both mobile **usage log and video** data.

Solution

Log Viewer — Link toggle & Task selector

Filter Function — Task Sheet — **Video Player**
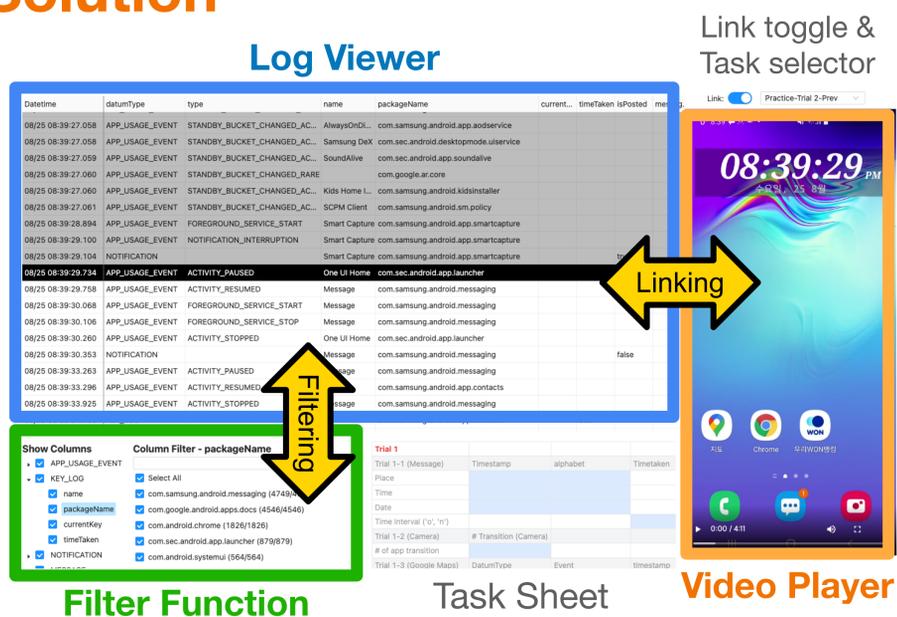
Log and Video Linker (LV-Linker) system: connect smartphone screen recorded video data and time series log data

System Features

- **Log Viewer**: Show processed logs in the form of a sheet
- **Video Player**: Show app usage video that records users' app usage behavior pattern on the smartphone
- **Filter Function**: Help select the dat they want to see

Additional Features for Evaluation

- **Link toggle & Task selector**: Provide options for tasks
- **Task Sheet**: Help conduct the analysis task in our system

System Evaluation

Tasks

1. App Keyboard typing analysis
2. Number of App transition time analysis
3. App usage start/end time analysis in different time
4. App usage start/end time analysis in continuous time

Conditions

- Prior Log Data Experience
  - Experienced (n=2)
  - Non-experienced (n=6)

- Task Order
  - Group A (Linked ➔ Unlinked)
  - Group B (Unlinked ➔ Linked)

Results

Taken Time	Source	d.f	F value	P		Taken Time	Source	d.f	F value	P
Total	A/B Session	1	2.612	0.12558		Total	LUL	1	5.63	0.011*
	E/N	3	6.628	0.00789**			E/N	1	10.80	0.006**
	A/B * E/N	3	3.746	0.03266*			LUL * E/N	3	0.467	0.709
	error	16					error			
Task 1	A/B Session	1	3.926	0.0245*		Task 1	LUL	3	1.705	0.2
	E/N	3	4.558	0.1929			E/N	1	2.268	0.149
	A/B * E/N	3	3.746	0.03266*			LUL * E/N	3	0.331	0.803
	error	16					error			
Task 2	A/B Session	1	0.242	0.6283		Task 2	LUL	3	6.91	0.00246**
	E/N	3	5.518	0.00674**			E/N	1	5.098	0.03592*
	A/B * E/N	3	3.262	0.04903*			LUL * E/N	3	0.521	0.67369
	error	16					error			
Task 3	A/B Session	1	3.528	0.0348*		Task 3	LUL	3	4.978	0.01026*
	E/N	3	1.119	0.3033			E/N	1	9.393	0.00638**
	A/B * E/N	3	0.343	0.7944			LUL * E/N	3	0.276	0.8419
	error	16					error			
Task 4	A/B Session	1	2.211	0.12		Task 4	LUL	3	2.25	0.115
	E/N	3	0.823	0.376			E/N	1	1.181	0.291
	A/B * 6/N	3	2.432	0.1028			LUL * E/N	19	0.259	0.854
	error	16					error			

Helpfulness Survey (Helpfulness (1. Not at all helpful ~ 5. Extremely Helpful))

	Task 1	Task 2	Task 3	Task 4	Overall Task
Correctness	2.8	2.8	3.4	3.3	3.3
Quickness	3.5	3.0	3.5	4.0	3.5
Data Understanding	2.4	2.3	3.1	3.0	3.6

NASA Task Load Index

| Mental Demand		Physical Demand		Temporal Demand		Effort		Performance		Frustration	
Unlinked	Linked	Unlinked	Linked	Unlinked	Linked	Unlinked	Linked	Unlinked	Linked	Unlinked	Linked
7.75	5.88	8.50	5.50	8.13	5.63	8.38	5.88	5.13	3.00	6.63	5.25

Task Completion Time

- Group A < Group B in Task 1, 3
  - Linked system help users to understand the log data
- Linked ≠ Unlinked in Task 2, 3
  - More difficult task → More effective
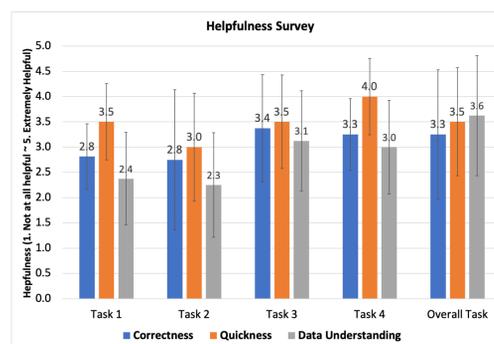
Helpfulness for each task

- 75% of respondents answered that the linked system is more helpful in terms of data understanding, correct & quick usage behavior analysis.
- The more difficult the usage behavior analysis task is, the more helpful the linked system (Task 3,4 > Task 1,2)
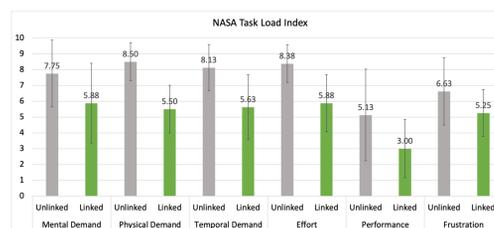
Task Workload

- Linked < Unlinked
  - A linked system helps reduce the overall task load, especially physical demands
  - A linked system minimizes scrolling and reduces fatigue from the task.

Conclusion and Future Work

- Proposed an **interactive visualization tool** that supports a linked view of smartphone usage log and video data.
- Verify the **effectiveness** of smartphone user behavior analysis through **quantitative and qualitative evaluation.**
- Enhanced to examine **data quality issues** and identify the user behavior analysis of various **touchscreen-based smart devices.**