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E^3: Visual Exploration of Spatiotemporal Energy Demand

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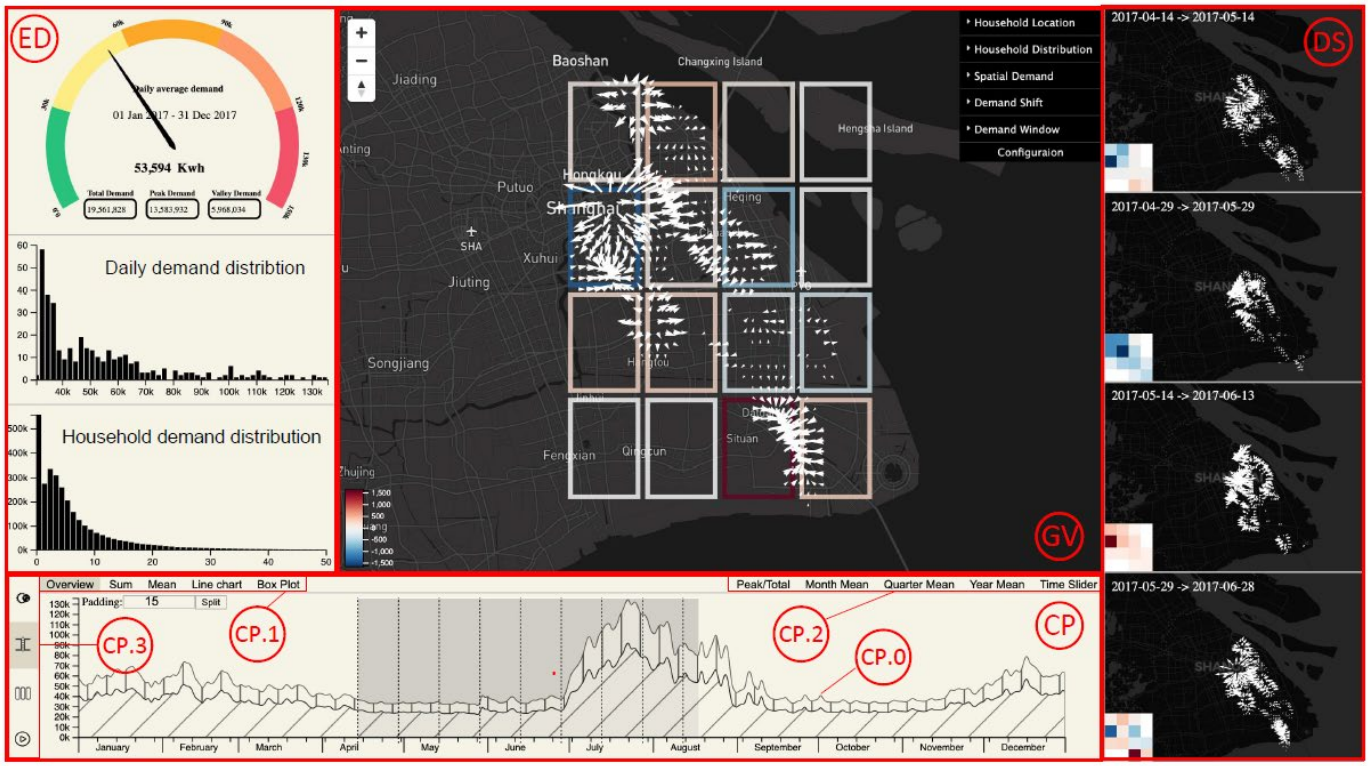
Introduction

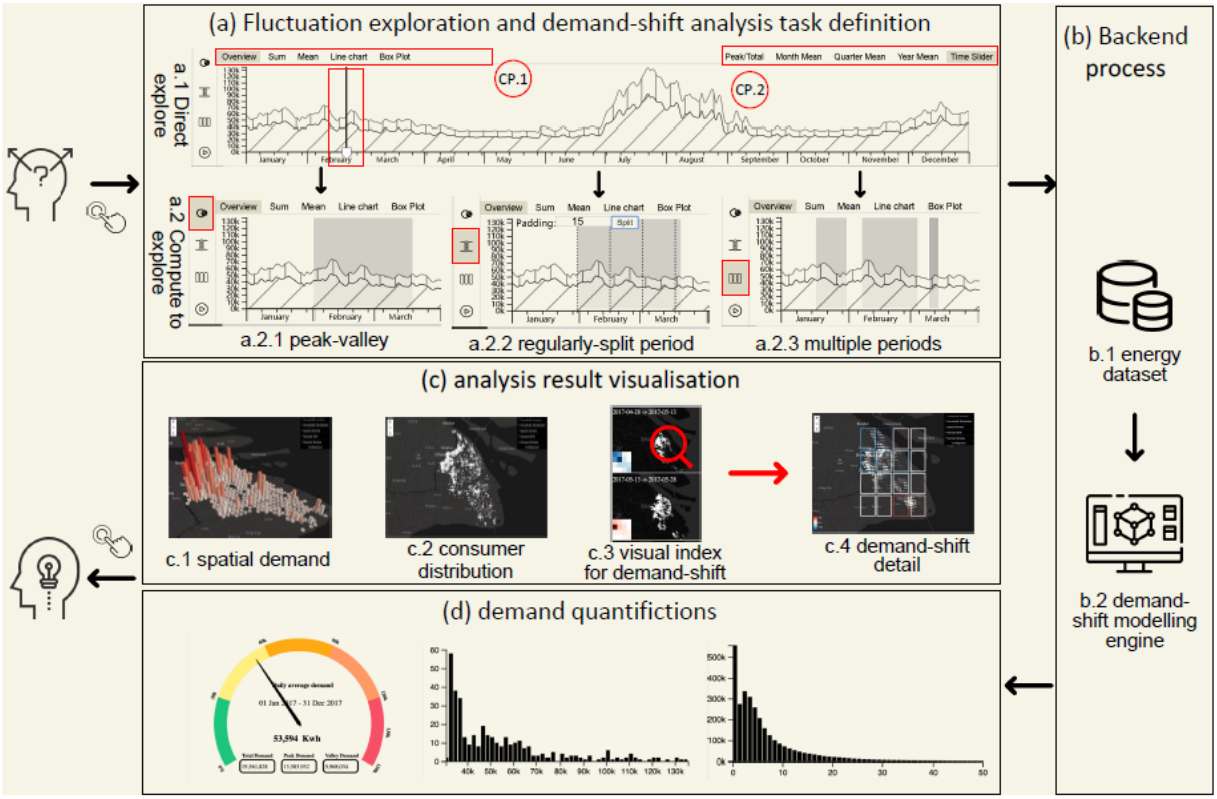
Understanding **demand-side energy behavior** is critical for making efficiency responses for energy demand management. We have identified the key elements of the energy demand problem including temporal, spatial demand and shifts.



The interface of our system

To our knowledge, no previous research has investigated the demand shifts in the spatiotemporal space. To fill this research gap, we propose a unified visual analytics approach to support exploratory demand analysis; we developed E^3, a highly interactive tool that support users in making and verifying hypotheses through human-client-server interactions. A novel potential-flow-based approach was formalized to model shifts in energy demand and integrated into a server-side engine. Experts then evaluated and affirmed the usefulness of this approach through case studies of real-world electricity data. In the future, we will improve the modelling algorithm, enhance visualization, and expand the process to support more forms of energy data.

The visual analysis pipeline



Experts can start to explore the fluctuation demand (a.1) and then explore the spatial dimension (c.1 and c.2). The auxiliary lines (view CP.1 and CP.2) and demand quantifications (d) will help them to understand the spatial and temporal demand characteristics. With the initial exploration of temporal and spatial demand, experts may already have some hypothesis about the demand-shift. They can formalise the hypothesis into analysis tasks (a.2.1, a.2.2, a.2.3) interactively and the interface will send the settings to the backend demand-shift engine (see Section 4.3). The computed results are sent back to the visual interface (View GV and DS in Fig. 1). The users can choose the demand-shift from the index view (c.3) and analyse the details in the detail view (c.4). In such a way, the users can construct the hypothesis, verify the idea, and thus gain insights through a human-client-server interactive analysis loop, interactively and iteratively.

Main contributions

- We propose a visual analytic framework that enables experts to construct energy demand hypotheses, verify these hypotheses, and gain insights through an interactive human-client-server analysis loop.
- We propose a novel potential flow based approach to model the energy demand-shift and integrate it into the server-side engine.
- We develop E^3, a visual analytics tool with novel visualizations and interactions, for a thorough and efficient exploratory analysis of energy demands in temporal, spatial, and spatiotemporal dimensions.

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