A Distributed Optimization Framework for Human-Driven HVAC Control in Smart Buildings

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Power Management of HVAC in Smart Grid

- **Objectives of Power Management of Heating, Ventilation, and Air conditioning (HVAC) System:**
  Minimize electricity cost and satisfy customer’s request

- **Questions:**
  1. How to predict electricity charge in smart grid?
  2. How to evaluate customer’s satisfaction level?
  3. How to timely notify the HVAC system of users’ request?
  4. How to balance between multi-objectives?
HVAC Control in Multiarea Buildings

- **Traditional Control of HVAC by Thermostat:**
  1. No integration of real-time electricity cost in smart grid
  2. Cannot meet individual user’s request in a timely manner
  3. Energy waste in empty rooms/areas
  4. Change of location among different temperature areas may cause discomfort

- **Human-Driven HVAC Control**
  1. Settings of thermostat is driven by users’ real-time biofeedback: including skin temperature, heart rate and blood pressure.
  2. The biofeedback data is accessible by the nearby thermostats
  3. Each control unit serve for nearby movable users
  4. Novelty: hands-free control, timely tracking users’ comfort without location constraints
Approaches of Distributed Human Driven HVAC Control

- **Biofeedback measuring Equipment:**
  Smart watch with maturely developed techniques can measure individual biofeedback data, locate user’s position, and transfer data via wireless communication, i.e., Samsung's Simband smartwatch.

- **Integration of electricity charge rate:**
  In smart grids, current and future predicted electricity charge rate is available online.

- **A distributed control framework:**
  1. A local controller will schedule individual unit operation according to nearby users’ biofeedback data and charge rate.
  2. A coordination network will negotiate among all HVAC units to operate more efficiently and avoid peak power.
Challenges and Beneficial Objects of Proposed Work

**Major Problem to Be Solved:**

\[
J = \min_{u_i} \sum_{t=1}^{T} \sum_{i=1}^{N} \left[ C_{i,t}(x_i(t), u_i(t)) - U_{i,t}(x_i(t), u_i(t)) \right]
\]

- **Electricity Cost**
- **Users’ Comfort Level**

subject to \( x_i(t+1) = f_i(x_i(t), u_i(t)), \) \( S(x_1(t), \ldots, x_N(t)) = 0, \) for all \( t, i \)

**Challenges:**

1. Establishing a precise conversion relationship between biofeedback data and users’ comfort evaluation function \( U_{i,t}(x_i(t), u_i(t)) \)
2. Designing local optimal control algorithm to solve the optimization problem with dynamic objectives and nonlinear constraints
3. Developing an efficient coordinating schemes

**Beneficial Objects:**

1. Buildings with multiple rooms and scattered users, i.e., hospital, shopping center, and schools
2. Disabled people, infants or sleeping users without access to traditional thermostats