



JoyDigit NexIoT: An Open IoT Data Platform for Senior Living

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Abstract. The senior care service plays an important role in senior living industry. With the unprecedented increasing of the seniors and the demanding activities of daily living (ADL) service, caregiver's workload and community's operational cost grow dramatically which lead tremendous challenges. From both caregivers and community operators' perspective, we developed an open IoT data platform for senior living named JoyDigit NexIoT to solve above problems. Multidimensional open IoT data from smart home, health care equipment and security monitoring devices are integrated and processed in real-time on the platform to build dynamical profiles for both seniors and communities, and it also provides open data APIs for customized senior living applications. Together with the novel JoyDigit Intelligent Action Adviser (JIAA), the platform outputs the recommended service or management actions to caregivers and operators, which could greatly reduce the caregiver's daily workload and increase community operator's management efficiency. In this paper, we describe JoyDigit NexIoT platform's features, architecture and JIAA, and also present the practical scenarios to be demonstrated.

Keywords: Data platform · Internet of Things · Intelligent Action Adviser

1 Introduction

The senior care service occupies most of workloads in senior living communities. The utilization of IoT technologies [4] and applications, like bed exit alarm [5], sleep analysis [6] and etc., relieves the caregiver's stress and workload. And IoT platforms are used for connecting heterogeneous IoT devices and building own applications. Comparing with general IoT platforms [1,2] which emphasizes on Platform as-a Service (PaaS), the IoT platform for senior living is much more care operation oriented. AIP (aging in place) service platform [3] that allows people to use composition tool to build medication reminder together with light and sound. HABITAT [7] monitors the daily behaviors of people by

embedding the IoT devices in everyday life objects like wall light, armchair, belt and wall panel etc. The IoT silos are built for individual scenarios and not integrated. More importantly, except for the routine service plan, caregivers and operators need intelligent action adviser based on comprehensive data insight from multidimensional IoT data, senior's profile and community regulations.

We implemented an open IoT data platform called JoyDigit NexIoT for senior living. It has following features:

Open IoT Management. Adaptor technology is used for IoT data connection via third party IoT vendor cloud and APIs. Multidimensional IoT data are transformed and indexed in the hierarchy of locations like building, floor, area, room, senior and device which facilitate the further data access and analysis for certain layer directly and easily.

Open Data Application Builder and Marketplace. The building blocks like authorized public open data APIs and interactive data visualization are supported in the platform, and customization of IoT application is developer friendly.

Novel Intelligent Action Adviser (JIAA). Based on adaptive rule engine and user profiling, JIAA provides the recommended actions for caregivers and operators for better service management and regulation compliance.

2 Platform Architecture and Implementation

JoyDigit NexIoT's platform architecture is shown in Fig. 1. IoT Adaptor module is the open wrapper that customized to connect the devices via device cloud or APIs. The multidimensional IoT data from multiple devices are merged and stored according to the location of hierarchy. The platform provides building blocks like open data APIs and powerful interactive data visualization tool. Based on the building blocks, senior living IoT applications could easily constructed and released to Marketplace. Both the Building Blocks and applications in Marketplace act as the inputs for the JoyDigit Intelligent Action Adviser, JIAA, which outputs the proper actions to caregivers and operators according to the Adaptive Rule Engine algorithm and User Profiling. The action's positive feedback loop will greatly reduce the front-line caregiver's workload and work pressure, and improve the senior's service quality.

3 JoyDigit Intelligent Action Adviser and Algorithm

JIAA is built upon the adaptive rule engine and user profiling.

3.1 Definitions

Definition 1 (Rule). *Rule: $ActivityPattern(AP) \rightarrow Action$ where $AP = ActivitySteps(S) \times Time(T) \times Locality(L)$, and $ActivitySteps(S)$ are derived from multidimensional IoT data within specific time T and locality L .*

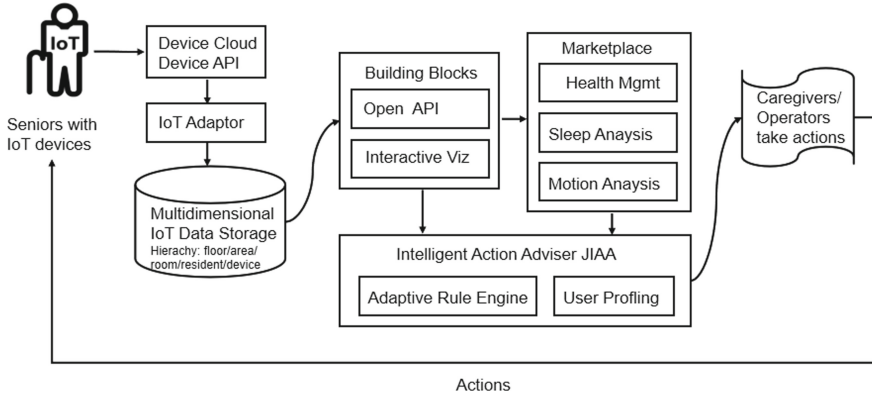


Fig. 1. JoyDigit NexIoT platform architecture.

e.g. the $AP_{insomnia}$ can be simply characterized by fail to fall asleep during the night time. $S_{insomnia} = (BodyMovment|BedExit)^*$ as regular expression which generated from IoT data from smart mattress. $T_{insomnia} = \{time|21:00 \leq time \leq 05:00\}$ as configuration parameters. $L_{insomnia} = \{locality|locality \text{ is bed room}\}$ as the location enumeration.

Definition 2 (UserProfile). The *UserProfile(UP)* for senior_{*i*} is Rule set for senior_{*i*}. $UP_{seniori} = \{Rule \mid Rules \text{ on senior}_i \text{ should be checked}\}$.

e.g. $UP_{Jim} = (AP_{insomnia} \rightarrow MedicineAction, AP_{bedexit} \rightarrow Assistance Action)$

3.2 JIAA Algorithm

We briefly introduce the JIAA algorithm, and it has three parts, the rule initialization, adaptive rule generation and rule check on user profile. As rule check is almost self-explained, we will focus on the first two parts.

Rule Initialization. Some initial rules are mandatory rules according to regulations and globally effective, called GlobalProfile. Other rules are manually built according senior_{*i*}'s care assessment and care plans, and tagged in corresponding $UP_{seniori}$.

Adaptive Rule Generation. Take all senors' daily activity steps as input, JIAA uses hybrid methods to generate the rule in adaptive ways.

a. *Common activity pattern generation.* We use the association rule algorithms like Apriori to discover the frequent activity patterns. These common patterns indicate we should provide standard service and work flow to reduce operation cost.

b. Outlier activity pattern generation. With predefined high-risk activities (e.g. falling, lost), we use statistic and data visualization (e.g. sankey diagram [8]) to get the preceding abnormal activities (called outliers) which lead to those predefined high-risk activities. The caregivers and operators should place more attentions and timely actions to these outlier patterns, because if not handled properly, they will lead the occurrences of the high-risk activities and high work pressure for caregivers and operators.

4 Demonstration Scenarios

Following scenarios will be demonstrated:

Platform's Open Capability. Take senior living health management as example to show the platform's open capability to IoT devices and data applications.

JoyDigit Intelligent Action Adviser. The IoT environment for insomnia rule detection as mentioned in Sect. 3.1 is setup with smart mattress and motion sensors. The end-to-end work flow of JIAA from rule definition, match and medication action triggered are demonstrated (in Fig. 2).

The screenshot displays two panels from the JoyDigit JIAA interface. The left panel, titled 'Smart Mattress Settings', includes configuration options for Device, Monitoring time, Normal heart rate, Normal respiration rate, Bed-exit duration exceed, and Bed-exit count exceed, each with input fields and units. The right panel, titled 'Warning Info', shows patient details (Name: Grandpa Zhao, Gender: M, Age: 88, Room: 510) and a 'Bed-exit' alert. It includes a 'Take Action' button and a table of recent warnings.

Item	Description	Warning Time	Action
Insomnia	Bed-exit exceeds 5 times	1970-01-01 08:00:02	Done
Smoking	Smoke detected	1970-01-01 08:00:02	Done

Fig. 2. JIAA with insomnia rule demonstration.

5 Conclusion

In this paper, JoyDigit NexIoT, an open IoT platform for senior living with novel Intelligent Action Adviser (JIAA) embedded, is introduced. The platform was deployed in some of senior living communities in China and received positive feedback with the caregiver's daily workload reduced and community operator's management efficiency increased.

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