

Samsung Ballie: A Technical Study of Intelligent Home Robotics

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Abstract:

Ballie is an AI-enabled home robot developed by Samsung to provide personalized assistance and interaction within a home environment. This paper examines the technologies and working principles that enable Ballie to function as a mobile home companion. The study focuses on its sensing and perception, autonomous mobility and navigation, artificial intelligence and multimodal processing, Tizen OS, human-robot interaction, projection capability, and smart-home integration. These technologies work together to help Ballie understand its surroundings, respond to user requests, move autonomously, project information, and interact with connected home appliances. Overall, Ballie demonstrates how robotics and AI can be integrated to create a more intelligent and interactive smart-home companion.

Keywords — *Ballie, Artificial Intelligence, Multimodal AI, Human-Robot Interaction, Autonomous Mobility, Smart Home, Tizen OS, Service Robot, Projection Technology*

I. INTRODUCTION

Robots are programmable machines designed to perform various tasks and assist humans in their daily activities. They can perform repetitive or complex tasks with consistency and efficiency, thereby reducing human effort. The capabilities of robots have evolved over time, with traditional robots following predefined instructions while autonomous robots can sense their environment, analyse information, make decisions and perform appropriate actions. This enables autonomous robots to respond to different situations [1].

Earlier autonomous robots were mainly designed for specific tasks such as mapping, localization and navigation. Some systems also considered human movement and comfort, showing that robots could navigate and perform useful tasks autonomously.[2] However, earlier systems generally focused on individual functions. As robot capabilities developed, artificial intelligence became important for processing and analysing information, interpreting situations and supporting appropriate decision-making [1], [8]. These developments demonstrated that autonomous robots could perform navigation and interaction-related tasks

with reduced human intervention, but their capabilities were often limited to specific functions.

Ballie, a spherical yellow home robot developed by Samsung, is an example of an AI-enabled home robot. It is designed as a mobile companion that can interact with users and provide personalised assistance. Ballie can also project content and use artificial intelligence to interpret information obtained through its input systems and support decision-making.

This paper focuses on Ballie and examines its technologies, working principles and methodology. It discusses how its different technologies work together to enable Ballie to perform various tasks within a home environment.

II. SAMSUNG BALLIE

A. Overall System Architecture

The overall system architecture of Ballie consists of input, processing, decision and output. Ballie obtains information through its input systems, which include a camera that provides visual information, audio input that collects user commands or sounds from the surroundings, and environmental sensors that provide information about its surroundings.

While the input systems collect information, the information alone is not sufficient for Ballie to respond appropriately. It has to be processed and interpreted. Ballie uses Gemini's multimodal capabilities together with Samsung's language models to process and understand different types of information. The processed information is then interpreted to determine an appropriate response. Based on the situation, the system can adapt Ballie's behaviour and responses in real time [13]. This allows Ballie to respond to the user and perform different tasks according to the situation.

As an output of the overall process, Ballie can move around, interact with the user, project content, interact with connected home appliances and provide personalized assistance.

B. Sensing and Perception

Ballie requires information to understand its surroundings. Thus, Ballie uses sensing systems to collect information. There are cameras, audio inputs and environmental sensors used to perceive the environment [3], [4], [5], [6]. The camera provides visual information, which helps Ballie understand what is in front of it. The data obtained through the camera is one of the several types of input processed by AI.

Ballie also uses voice input to receive audio information. This input is used by Ballie to interact with the user and also to obtain information about sounds around it, similar to the camera. As Ballie supports multimodal processing, this input can be processed along with other input types.

Likewise, environmental sensors provide information about the surroundings of Ballie. This contributes additional information to the AI system. Therefore, Ballie can use different types of information together when interpreting a situation. The combination of these inputs provides complementary information about the environment. Then, multimodal processing interprets the information, helping Ballie understand the situation and provide an appropriate response [3], [7], [8].

C. Autonomous Mobility and Navigation

When discussing autonomous mobility, Ballie can move autonomously around the home, reach different locations and perform various tasks. Even though Ballie can move around, its movement is not random. It collects information about its surroundings while moving through its sensing systems [2], [4].

Using this spatial information, Ballie can determine a suitable path, move towards the required location and perform the assigned task [16]. To perform a specific task, the LiDAR sensor senses information about its

surroundings, which supports navigation. Based on this information, Ballie can move towards the required location and perform the task.

D. Artificial Intelligence and Multimodal AI Technology

As mentioned before, Ballie receives different types of inputs, but raw inputs alone are not enough. The AI system processes and interprets the collected information to help Ballie determine an appropriate response. Without AI, it would be difficult to interpret and combine different types of information to understand the situation and respond appropriately [7], [8].

Furthermore, there is multimodal AI technology. Multimodal means that a system can work with different types of inputs together. Ballie uses Gemini's multimodal capabilities. Samsung combines Gemini with its proprietary language models to help Ballie process different forms of input from its input systems [13]. As a result, the system can adapt Ballie's behaviour and responses in real time.

With these technologies, Ballie can understand user requests in different contexts. Ballie provides personalized assistance based on the behaviour and preferences of the user. It can also provide recommendations based on the information it processes. Additionally, Ballie can assist the user through schedules and reminders while adapting its responses according to the user's needs.

Whenever Ballie understands a user request, such as setting a reminder, the AI system processes the request and determines an appropriate action. Based on this understanding, Ballie can perform the required task.

E. Tizen OS and System Software

An operating system provides the software environment required for a device to run its functions and manage its overall operation [15]. In Ballie, Tizen OS is used as its operating system and forms part of the software platform that works together with the robot's sensing, AI and other system components.

Although Tizen OS is used in Ballie, it mainly provides the software foundation on which different services and capabilities can operate. Therefore, Tizen OS is not responsible for performing the entire function of Ballie by itself. Instead, it forms part of the overall software environment of the robot. According to Samsung, Tizen is a platform that connects operating-system functions, services and content across its device ecosystem.

F. Human-Robot Interaction

Ballie is not just a task-oriented robot. It is designed to interact with humans as a companion and provide a more natural form of interaction [9], [10], [11], [12]. When a user communicates with Ballie, its audio input receives the user's voice, which is then processed by the AI system to understand the request. Ballie's mobility is also an important feature, as it can move with the user instead of remaining in one fixed location.

Ballie can assist the user in different situations according to the request. For example, it can help with setting reminders, personalizing schedules and managing aspects of the home, such as adjusting lighting. These functions allow Ballie to provide assistance based on the user's requirements.

G. Projection and Visual Interaction

Another important output capability of Ballie is its projection capability. It can project content onto a wall or floor according to the situation. The content may include weather information, news and online videos [14]. Due to its mobility, Ballie can project content at locations that are convenient for the user.

Furthermore, the projection capability makes the interaction more visual instead of relying only on audio input.

H. Smart-Home Integration

Smart-home integration means how Ballie works with and interacts with other connected devices and appliances at home [14]. Ballie can connect with compatible home appliances and assist in managing different aspects of the home. The AI system of Ballie helps understand the user's request and interact with connected devices across the home. Thus, Ballie can function as a part of a smart-home environment [14].

I. Overall Working Process

The overall working process of Ballie involves the coordination of its sensing, AI, navigation and output systems. First, Ballie collects information from its different input systems, including the camera, audio input and environmental sensors [3], [4], [13]. The collected information is then processed using AI and multimodal capabilities to understand the user's request and surrounding situation. Based on the processed information, the system determines an appropriate response or action. If movement is required, Ballie's navigation system supports its movement towards the required location. Finally, Ballie performs the appropriate action, such as interacting with the user, projecting content or interacting with connected home appliances [13], [14].

III. CONCLUSIONS

Samsung Ballie shows how artificial intelligence and robotics can be combined to create a more interactive home companion. Unlike robots that are designed mainly for predefined tasks, Ballie can respond to users and provide assistance according to different situations. Its mobility and interaction capabilities allow it to operate more naturally within a home environment.

From the technologies discussed, it can be seen that Ballie's functionality depends on the cooperation of different hardware and software components. AI, sensing, navigation and connected services work together to support its functions. However, the effectiveness of the system can depend on how reliably these components operate together. Overall, Ballie represents the development of home robotics towards more intelligent and interactive systems.

ACKNOWLEDGMENT

The author acknowledges the guidance and support of Prof. Riya K Prakash and Prof (Dr). L.C Manikandan during the preparation of this study.

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