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Smart Service Solutions AI: AI-driven Multimodal Search for Home Appliance Support

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Abstract

The global home appliance services market is projected to reach USD 1,203.11 billion by 2032, driven by smart household appliances. Essential services like installations, maintenance, and repairs ensure optimal performance and longevity, leading to higher customer satisfaction and loyalty. The service station partner ecosystem is crucial for ongoing support and profitability. However, challenges such as identifying the right manuals, finding relevant parts, and providing accurate instructions must be addressed to enhance operational efficiency and maintain brand reputation. An AI-based solution can streamline the identification of manuals, parts, service stations and troubleshooting steps for home appliances by processing text, voice and images. This AI-based solution integrates Neo4j for data management and Multimodal Search with Retrieval-Augmented Generation (RAG) to enhance technician support for home appliance services. Neo4j efficiently organizes and retrieves comprehensive data of various home appliances, parts, and manuals, service stations, while the RAG system provides precise, contextually relevant instructions. The multimodal RAG system is particularly important as it leverages both text and images from manuals, ensuring technicians receive detailed, accurate guidance with visual aids such as drawings and diagrams. This approach significantly improves service efficiency, customer satisfaction, and operational effectiveness, and increases business. Evaluation metrics such as answer relevancy, context precision, and context recall validate the system's performance.

Keywords: AI, multimodal RAG, Neo4j, large language models (LLMs), multimodal large language models (MLLMs) home appliances, service

INTRODUCTION

The global Home Appliance Services market size was USD 745.8 billion in 2024. Increased usage of smart household appliances is expected to boost sales to USD 1,203.11 billion by 2032, with a Compound Annual Growth Rate (CAGR) of 6.50% from 2024 to 2031 [1–3]. The services such as installations, maintenance, and repairs are crucial for ensuring the optimal performance and longevity of home appliances and equipment. Timely and efficient service ensures that appliances function properly, reducing the likelihood of breakdowns and extending their lifespan. This leads to greater customer satisfaction and loyalty, as users can rely on their products to perform consistently and effectively.

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The service station partner ecosystem is an essential component of customer service [4], particularly in

the aftermarket and after-sales support sectors. While Original Equipment Manufacturers (OEMs) focus on product development and initial sales, service station partners play a critical role in providing aftermarket services such as installation, maintenance, repairs, and overall customer support. For customers, timely and efficient service from these partners ensures that their appliances and equipment continue to function optimally, enhancing both product performance and user satisfaction.

From a business perspective, especially for manufacturers and sales companies, the service station ecosystem is a significant driver of profitability. Aftermarket services often generate profit margins up to four times greater than those of new product sales. Reliable service stations help maintain the brand's reputation, reduce warranty claims, and increase the likelihood of repeat purchases or upgrades. Conversely, poor service or delays can lead to prolonged downtime, reduced appliance lifespan, and a poor overall user experience, ultimately resulting in dissatisfied customers, increased repair costs, and potential loss of business, which negatively impacts the company's reputation and revenue.

CHALLENGES FACED BY THE SERVICE PARTNER ECOSYSTEM

Identifying the Right User Manual

With thousands of home appliances from various manufacturers and models, finding the correct user manual, service manual, or installation manual for a specific product can be incredibly challenging. Each appliance might have different versions, spare parts, and service procedures. The vast number of manuals, parts' catalogues, and specifications increases the difficulty in pinpointing the correct document.

Finding Relevant Parts and Availability

Identifying the correct parts for a specific appliance model is a significant hurdle. Technicians need to ensure they have the right parts before arriving at the service location. This involves checking part numbers, compatibility with models, and ensuring the parts are available.

Providing Accurate Instructions

Delivering the right set of instructions for installation, service, or repair based on the specific problem reported by the user is another major challenge. Going through various manuals for these instructions is humongous and laborious task for the service providers.

Pre-Service Preparation

Ensuring that technicians have complete information about the appliance, including model details, manuals, parts, and costs, before arriving at the service point is crucial for efficient and on time service delivery.

Time and Resource Constraints

Technicians typically work in high-pressure environments, where time is limited. Delays in finding the correct manual, parts, or diagnostic procedure can lead to extended service times and increase in customer dissatisfaction.

Lack of Real-Time Information

Service stations often lack a unified system for real-time access to product and parts data. This leads to inefficiencies as technicians might need to contact multiple sources or rely on outdated or incomplete information.

Managing Large Volume of Products and Manufacturers

The sheer volume of products and manufacturers, each with its own set of standards and instructions, makes it more difficult to manage and retrieve information effectively. Technicians must navigate a complex ecosystem of different manufacturers' specifications, service histories, and guidelines real time with good network connectivity.

WHY ADDRESSING SERVICE PARTNER ECOSYSTEM CHALLENGES IS CRUCIAL

- *Customer satisfaction:* Timely and accurate service ensures appliances function properly, leading to higher satisfaction and loyalty. Delays can frustrate customers and increase costs.
- *Operational efficiency:* Efficient identification of manuals and parts reduces downtime and speeds up service, improving overall efficiency.
- *Cost reduction:* Accurate pre-service preparation minimizes unnecessary trips to consumer locations and repair costs.
- *Brand reputation:* Reliable service maintains the brand's reputation and encourages repeat business.
- *Reduced downtime:* Ensuring technicians have complete information before service visits reduces appliance downtime and improves service delivery.

By addressing these challenges, the service partner ecosystem can significantly enhance its ability to provide timely, accurate, and efficient service, ultimately benefiting both consumers and businesses.

SOLUTION

How AI Can Address These Challenges

The AI based solution accepts the user requests regarding the installation or service/repair of any home appliances either through voice, through mail using the text or through uploading an image of the bar code of the home appliance. The voice content is converted into text using simple speech to text model [5, 6]. The application also has the facility to upload the barcode of the home appliance and send user request to the necessary steps to address the issue. The application has the module to process the image using the DeepSeek Janus model to extract the product details in text. The speech processing and image processing modules extract the key features like product name, model number, make, issue to be addressed, etc. from the user given input content. The extracted metadata is passed on to the Neo4J graph database to identify the relevant metadata along with the relevant manuals. These manuals are further processed using the multimodal RAG to get the step-by-step procedure to address the issue with the text and respective images, diagrams or any visual content that gives a detailed clear instruction to address the issue. Integrating knowledge graphs and vector retrieval augmented generation has shown efficient information extraction [7]. RAG has boosted the performance [8]. The AI-based solution for home appliance service and support operates through two key layers of processing. The solution architecture is presented in Figure 1.

Neo4j-Based Document Identification

The solution architecture leverages Neo4j, a powerful graph database, as a first layer, to maintain an interconnected ecosystem of appliance data, service station information, parts' catalogues, and relevant manuals. By cross-referencing appliance models and manufacturers with a database of available parts, the system identifies relevant documents, including user manuals, service manuals, and installation guides. This process drastically reduces the time spent searching for the right manual for a specific appliance.

Multimodal Semantic Search

The second layer involves a multimodal semantic search that considers text, images, graphs, and other visual content of the product manuals. This search capability ensures that technicians receive precise and contextually relevant instructions tailored to the specific issue, whether it is installation, repair, or general maintenance.

RAG

The RAG system enhances this process by generating comprehensive reports that combine textual instructions with corresponding images or diagrams. This integrated approach provides technicians with clear, understandable steps and visual cues to address the current issue effectively.

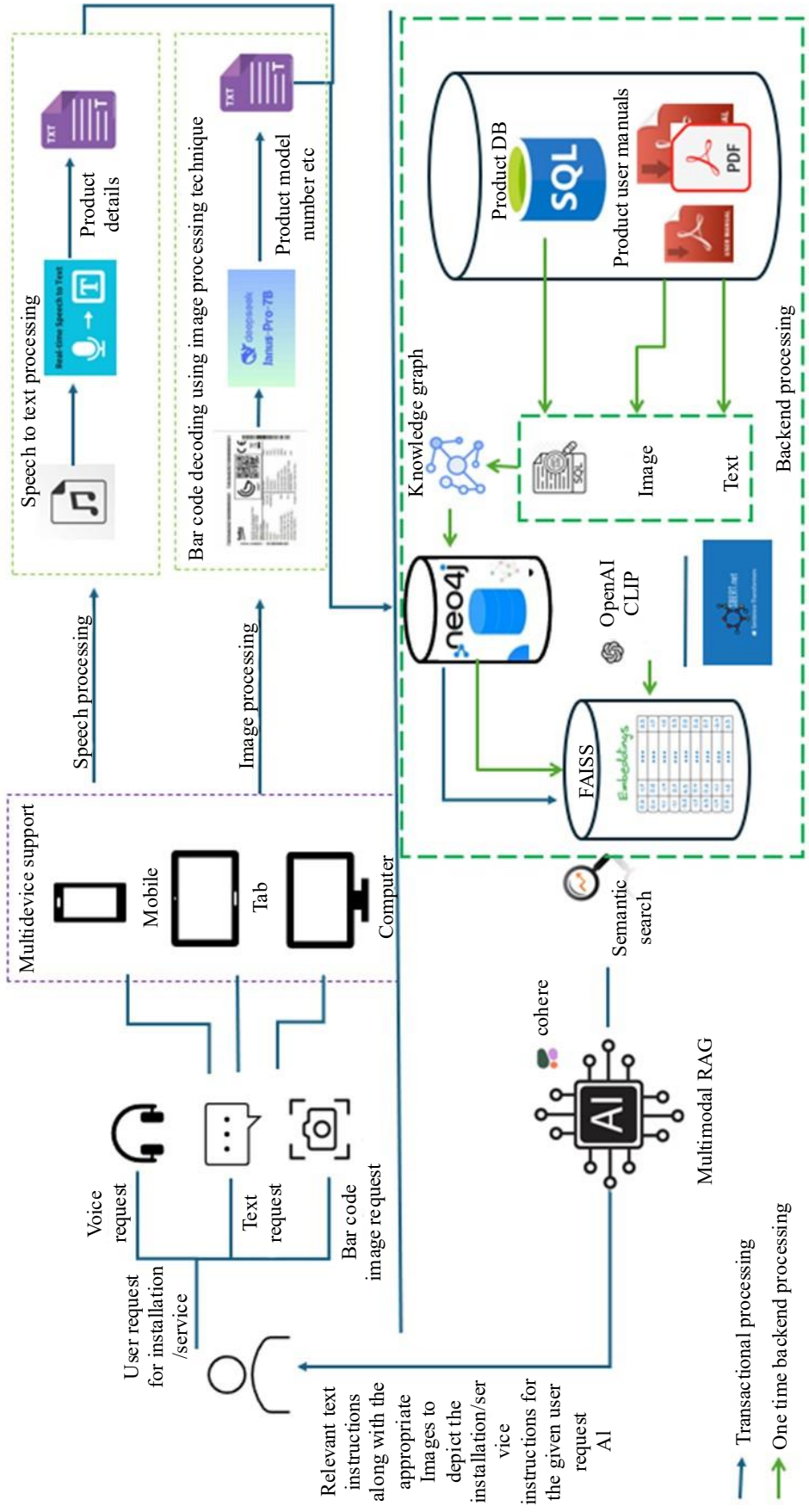


Figure 1. Solution flow architecture.

By leveraging AI to address these challenges, the service partner ecosystem can significantly enhance its ability to provide timely, accurate, and efficient service. This results in improved efficiency, faster service, increased customer satisfaction, cost savings, better service quality, and a competitive advantage in the market for the OEMs.

Neo4j Graph Database

The Neo4j graph database serves as the backbone of the system, storing and organizing comprehensive data related to home appliances, their parts, and service manuals. The database includes data like:

- *Appliance data:* Details of home appliances from various manufacturers, including device names, models, and makes.
- *Parts data:* Information about the parts associated with each appliance, including part numbers, availability, cost, etc.
- *Manuals data:* Links to appropriate manuals such as installation, service, disassembly, and repair manuals for each appliance.
- *Service stations data:* Information about service station partners, including addresses, nearby service stations, and the ecosystem of service partners.

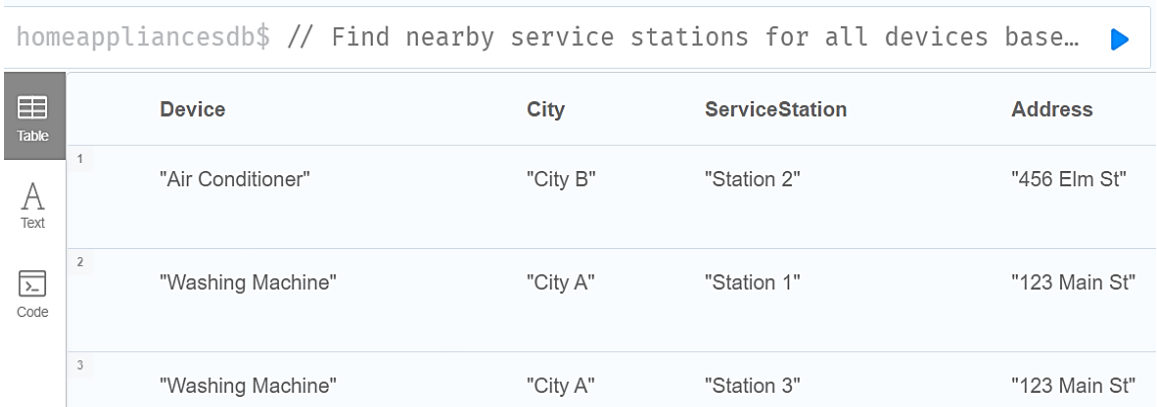
Few snapshots of graph databases for the home appliances are presented in Figures 2–6. Few sample queries are:

- List all nearby service stations for home appliance products in my city, including their contact details and locations. The results are illustrated in Figure 2.
- Retrieve comprehensive details of all home appliance products available in nearby stores. The results are presented in Figure 3.
- Display service manual information for each product. The information is shown in Figure 4.
- Present a graphical view illustrating the connections and relationships between product details. This visualization is depicted in Figure 5.
- Visualize all products along with their respective relationships in a detailed graph format. The comprehensive graph is shown in Figure 6.

Data Retrieval via Graph Database Search Engine

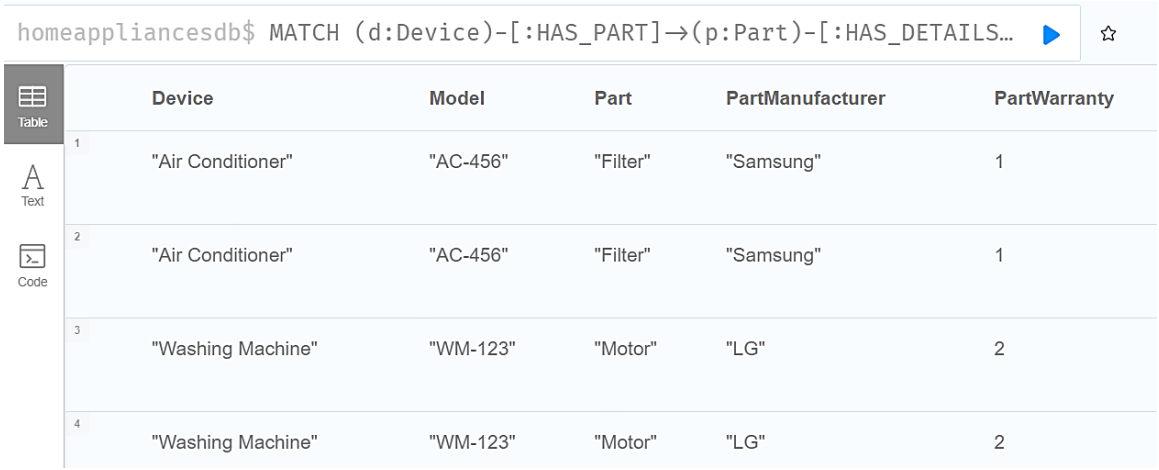
The system efficiently queries the Neo4j graph database using specific user inputs, such as:

- *Appliance make and model:* To narrow down the search to the exact product.
- *Device issue or service type:* To identify the appropriate service manuals (installation, repair, troubleshooting, regular maintenance) or parts.
- *Part numbers or availability:* To locate and verify the parts required for service or repair, along with their current availability and pricing.



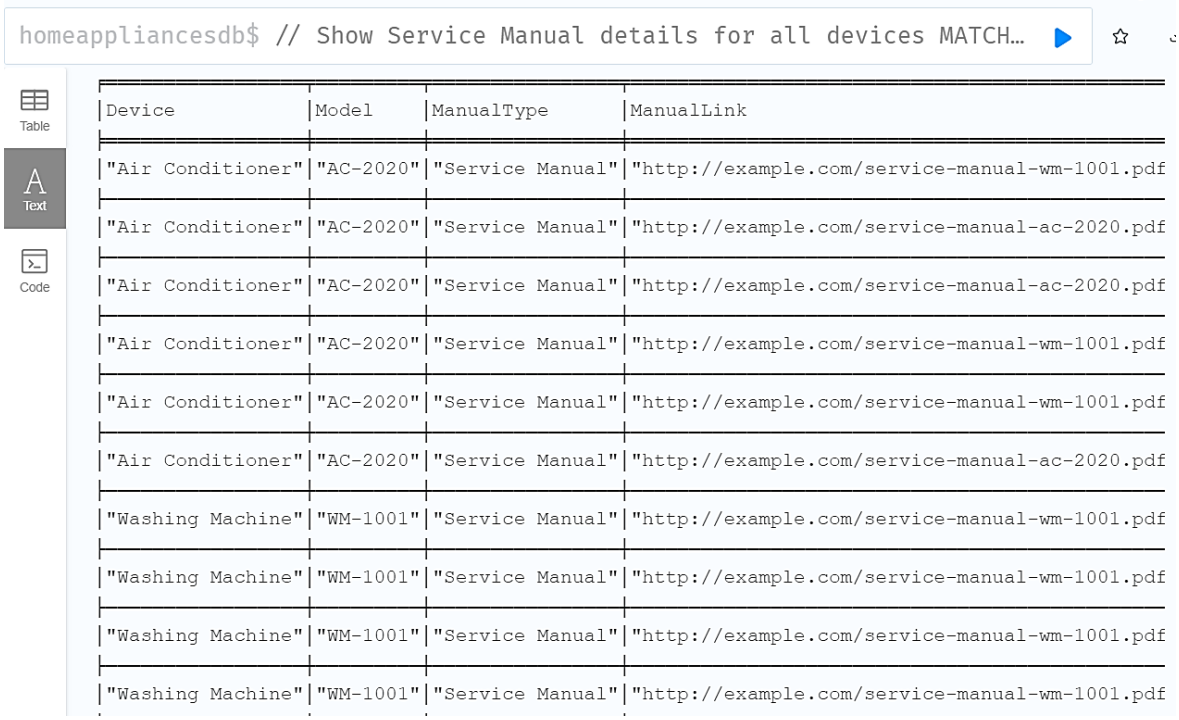
	Device	City	ServiceStation	Address
1	"Air Conditioner"	"City B"	"Station 2"	"456 Elm St"
2	"Washing Machine"	"City A"	"Station 1"	"123 Main St"
3	"Washing Machine"	"City A"	"Station 3"	"123 Main St"

Figure 2. Nearby service stations for home appliance products in the city, including contact details and locations.



	Device	Model	Part	PartManufacturer	PartWarranty
1	"Air Conditioner"	"AC-456"	"Filter"	"Samsung"	1
2	"Air Conditioner"	"AC-456"	"Filter"	"Samsung"	1
3	"Washing Machine"	"WM-123"	"Motor"	"LG"	2
4	"Washing Machine"	"WM-123"	"Motor"	"LG"	2

Figure 3. Comprehensive details of all home appliance products available in nearby stores.



Device	Model	ManualType	ManualLink
"Air Conditioner"	"AC-2020"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf
"Air Conditioner"	"AC-2020"	"Service Manual"	"http://example.com/service-manual-ac-2020.pdf
"Air Conditioner"	"AC-2020"	"Service Manual"	"http://example.com/service-manual-ac-2020.pdf
"Air Conditioner"	"AC-2020"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf
"Air Conditioner"	"AC-2020"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf
"Air Conditioner"	"AC-2020"	"Service Manual"	"http://example.com/service-manual-ac-2020.pdf
"Washing Machine"	"WM-1001"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf
"Washing Machine"	"WM-1001"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf
"Washing Machine"	"WM-1001"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf
"Washing Machine"	"WM-1001"	"Service Manual"	"http://example.com/service-manual-wm-1001.pdf

Figure 4. Service manual information for each home appliance product.

When a technician inputs the model and issue, the system retrieves:

- *Relevant manuals:* Direct links to installation, service, and repair manuals.
- *Parts details:* The specific parts required for the repair and their availability status.
- *Service station locations:* Nearby service stations, their addresses, and contact details for technician dispatch.

Neo4j's graph-based structure significantly reduces search effort and enhances the accuracy of results by understanding the relationships between appliances, parts, manuals, and service stations. This structured approach ensures that:

- The right set of manuals is retrieved for the specific model and make at the right time.
- Technicians have instant access to both the service instructions and parts needed for each issue.
- All data is interrelated, allowing for holistic and context-aware searches, improving efficiency and reducing human error.

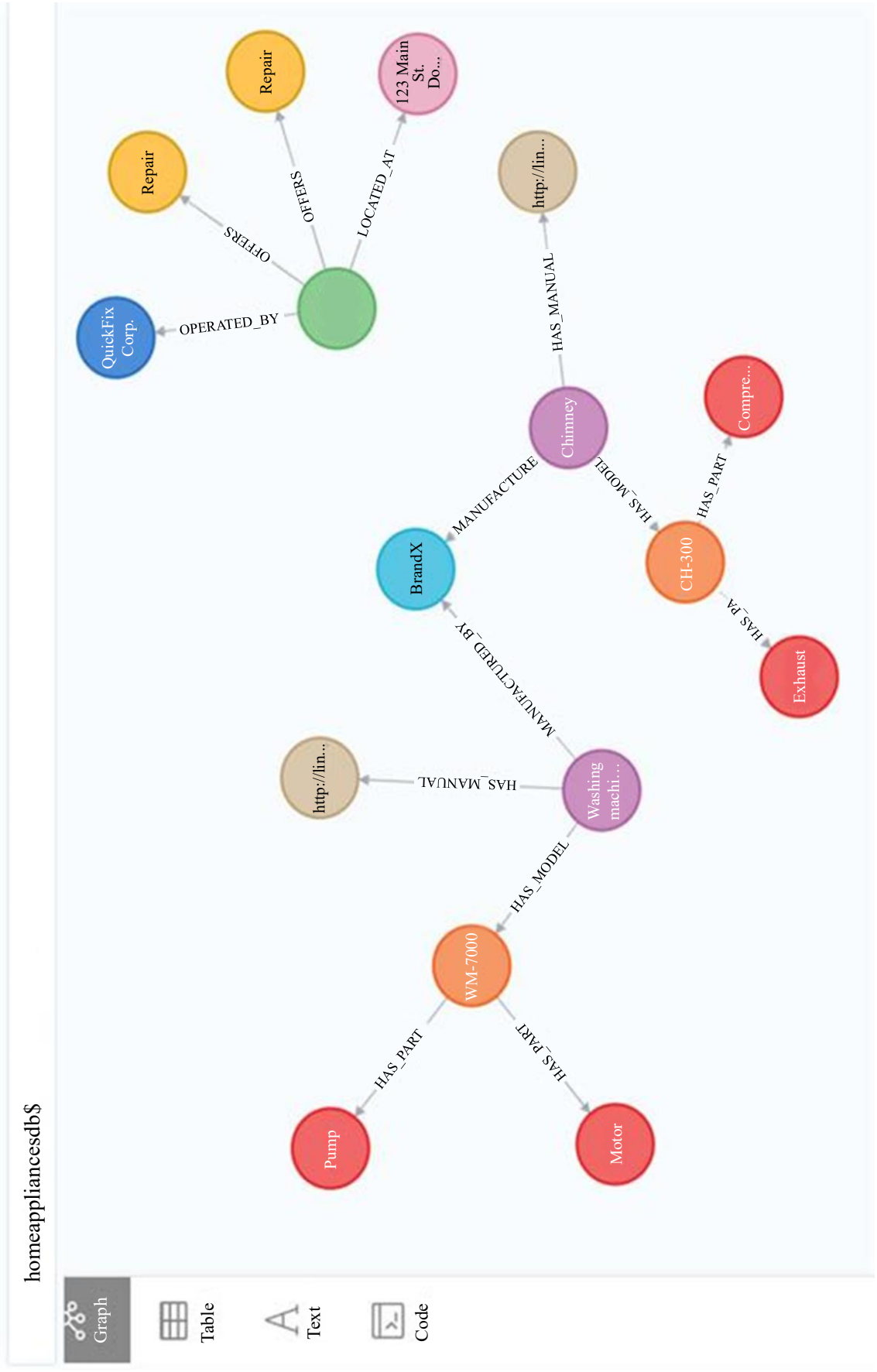


Figure 5. Graphical view of illustrating the nodes and relationships of products.

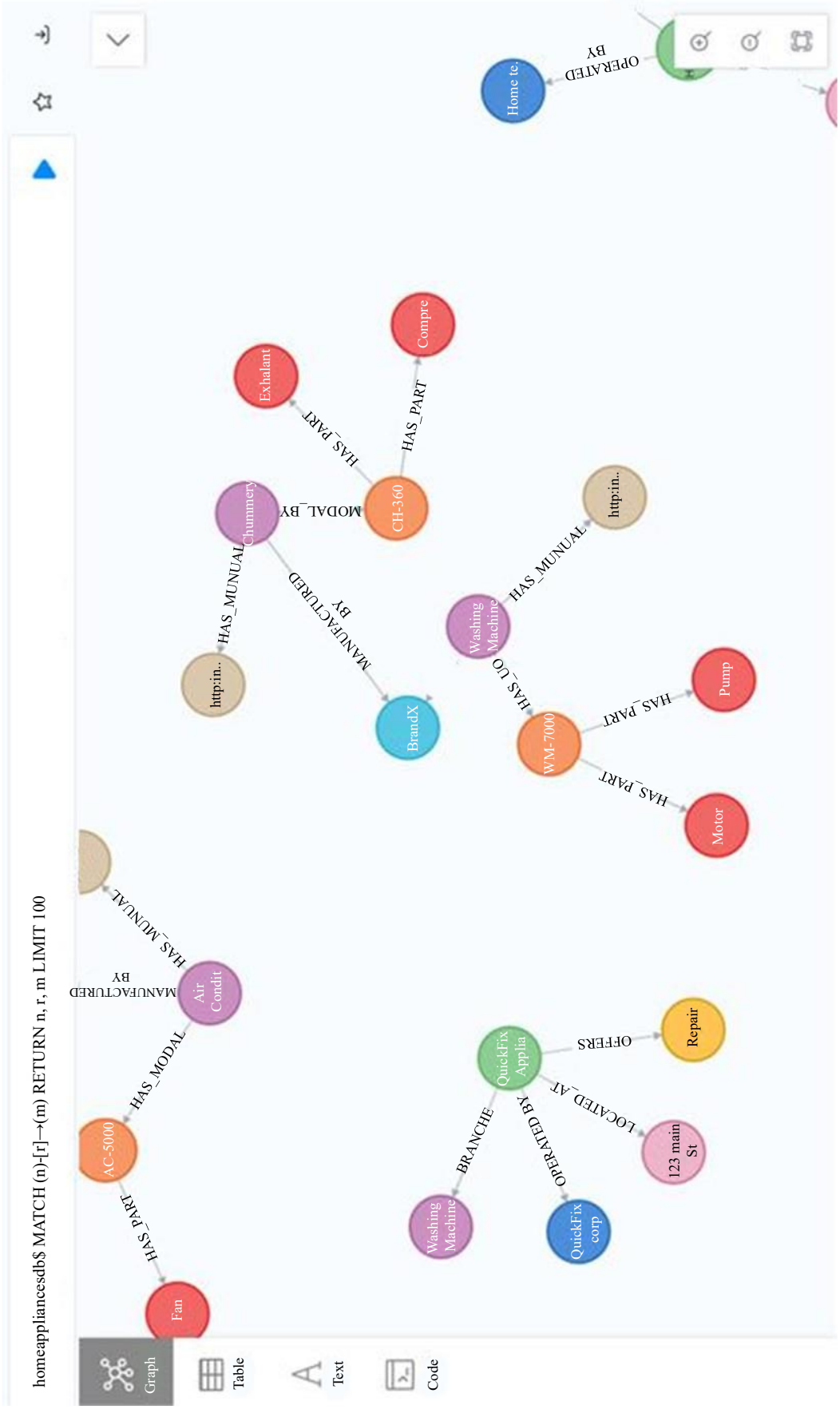


Figure 6. Visualization of all products along with their respective relationships.

In summary, the use of Neo4j in this solution ensures a robust and efficient system for managing and retrieving detailed information about home appliances, their parts, service stations and service manuals.

Multimodal Search and RAG for Technician Support

The Multimodal Search and RAG system is a key component of the solution, designed to provide technicians with relevant instructions for addressing home appliance issues. The manuals have different types of instructions:

- *Installation:* Steps for setting up an appliance or component.
- *Service:* Regular maintenance procedures or troubleshooting.
- *Repair:* Instructions for fixing or replacing faulty parts.
- *Disassembly:* Guidelines for safely dismantling appliances. Manuals often include both text and images or diagrams that provide step-by-step instructions. These visuals guide technicians on parts, fixes, installation, and disassembly.

Challenges Without Multimodal Search

Without an efficient multimodal search system, a technician may struggle to find the appropriate guidance. For example:

- A technician may be searching for repair instructions, but the system may only provide textual descriptions, which could be insufficient or unclear, especially when the problem requires the replacement of parts that must be identified visually.
- If only text-based manuals are available, technicians may miss important visual cues (such as diagrams, exploded views of devices, or step-by-step images) that are essential for performing the repair or installation correctly.

This gap in information could lead to errors, longer service times, and suboptimal outcomes for the customer. To address the above challenges, multimodal solution architecture has been adopted to identify the most relevant set of instructions along with the respective visual content. This is achieved using the MLLM based semantic search, where the manuals are processed at the backend to get the embeddings of both text and images and stored in a single vector space. The RAG system helps to generate the set of instructions with text and respective images to give the final instruction to the technician. The combination of text and visuals ensures that technicians can accurately follow the guidance, improving efficiency and accuracy in performing tasks.

How Multimodal Search and RAG Improve the Process

The Multimodal Search with RAG system addresses these challenges by enabling the retrieval of both relevant text and images/diagrams that are specifically tailored to the technician's issue. Here is how this works: *Example: Input processing and query formulation:* The technician provides an issue description through text or voice input, such as:

- "Repair washing machine, drum not spinning."
- "Install dishwasher in kitchen."
- "Disassemble air conditioner unit."

The system processes this input, identifying the relevant metadata (device model, issue type, etc.) and formulates a query that searches the Neo4j database for the most relevant documents and media.

Retrieval of Relevant Documents

Using the data retrieved from Neo4j, the system identifies the manuals, and then manuals are used to give relevant instructions to the technician's needs. This includes:

- *Textual instructions:* Step-by-step repair or installation processes, troubleshooting tips, and safety guidelines.
- *Visual aids:* Relevant images, diagrams, exploded views of parts, and assembly guides that help technicians understand complex procedures more clearly.

RAG

The RAG model enhances this process by using semantic search to ensure that the most contextually relevant text and images are selected. The model analyzes both the textual descriptions and visual content, ensuring that the instructions provided are not only correct but also highly specific to the task at hand. For example, if the technician is performing a repair on a washing machine, the RAG system will prioritize retrieving:

- Step-by-step repair instructions for the washing machine drum issue.
- Images or diagrams showing the location of the drum, parts to check, and step-by-step repair processes.

This integrated approach ensures that the technician has everything they need in one place: clear, understandable instructions and visual cues to make the repair or installation process as smooth as possible. In summary, the multimodal search capability is an integral part of the solution, enhancing the overall service experience by providing technicians with comprehensive, accurate, and easy-to-follow instructions.

TECHNOLOGY STACK

The solution utilizes a robust technology stack including Neo4j for graph database management [9], Python for backend development, and LLMs) and MLLMs for natural language processing. Cohere [10] and Clip [11], DeepSeek Janus pro 7B [12] are used for generative AI and image processing, respectively, while Sentence Transformer mini L6 [13, 14] and FAISS facilitate efficient semantic search and similarity indexing. Additionally, speech-to-text libraries enable the processing of voice inputs.

RESULTS AND EVALUATION METRICS

To showcase the capabilities of the AI application, a practical use case involving washing machine manuals is selected. The application is designed to assist users with both the installation process and ongoing maintenance or repair tasks. Users can interact with the system through multimodal queries, combining text and images, to receive precise, contextual guidance. The application is built to ensure full traceability of the provided information. Each response to a user query consists of three key elements:

1. The actual answer or instruction;
2. The contextual content or reference from the manual on which the answer is based; and
3. The relevant images that support or illustrate the response.

This structure enhances user confidence and transparency, allowing users to verify the origin of the information. The following sample queries are categorized based on their functional domain. These queries demonstrate the application's ability to assist users with step-by-step guidance during the setup of the washing machine:

Query 1: "Provide the step-by-step procedure to remove the transportation locks from the washing machine". The multimodal search results for query 1 are presented across Figure 7(a)–(c), showing the response in Figure 7(a), the contextual information in Figure 7(b), and the related images in Figure 7(c).

Query 2: "List the various parts of the washing machine along with detailed descriptions of each component as specified in the manual." The detailed parts' information for query 2 is presented in Figure 8(a)–(c), showing the response in Figure 8(a), the contextual information in Figure 8(b), and the related images in Figure 8(c).

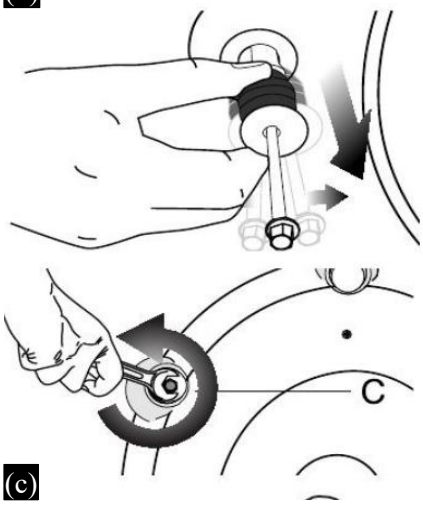
Query 3: "What are the steps to connect the water supply hose? Please include the relevant images from the manual". The instructions for connecting the water supply hose in query 3 are presented in Figure 9(a)–(c), showing the response in Figure 9(a), the contextual information in Figure 9(b), and the related images in Figure 9(c).


```
Response: 1. Loosen all the bolts with a spanner until they rotate freely.
2. Remove transportation safety bolts by turning them gently.
3. Attach the plastic covers supplied in the User Manual bag into the holes on the rear panel.
```

(a)

```
Context: Arcelik Washing MachineUser's Manual 5083 FYE/5104 FYE
Removing packaging reinforcement
Tilt the machine backwards to remove the packaging reinforcement. Remove the packaging reinforcement by pulling the ribbon.
Removing the transportation locks
A Do not remove the transportation
locks before taking out the packaging reinforcement.
A Remove the transportation safety
bolts before operating the washing machine, otherwise, the product will be damaged.
1. Loosen all the bolts with a spanner until they rotate freely (C).
2. Remove transportation safety bolts by turning them gently
3. Attach the plastic covers supplied in the User Manual bag into the holes on the rear panel. (P)
Keep the transportation safety bolts in a safe place to reuse when the washing machine needs to be moved again in the future.
Never move the product without the transportation safety bolts properly fixed in place!

Connecting water supply
The water supply pressure required to run the product is between 1 to 10 bars (0.1 – 10 MPa). It is necessary to have 10 – 80 liters of water flowing from
the fully open tap in one minute to have your machine run smoothly. Attach a pressure reducing valve if water pressure is higher.

If you are going to use the double water-inlet product as a single (cold) water-inlet unit, you must install the supplied stopper to the hot water valve
before operating the product. (Applies for the products supplied with a blind stopper group.)

If you want to use both water inlets of the product, connect the hot water hose after removing the stopper and gasket group from the hot water valve.
(Applies for the products supplied with a blind stopper group.)

Models with a single water inlet should not be connected to the hot water tap. In such a case the laundry will get damaged or the product will switch to
protection mode and will not operate.

Do not use old or used water inlet hoses on the new product. It may cause stains on your laundry.

1. Connect the special hoses supplied with the product to the water inlets on the product. Red hose (left) (max. 90 ºC) is for hot water inlet, blue hose
(right) (max. 25 ºC) is for cold water inlet.
Page number:  2
```

(b)



(c)

Figure 7. (a) Response to query 1 displaying the step-by-step instructions for removing transportation locks from the washing machine. (b) Contextual information related to query 1 providing additional relevant details. (c) Images associated with the query results illustrating the procedure.
(Image courtesy: BEKO, Washing Machine User Manual: 5083 FY & 5104 FY.)

```
Response: - Water Supply Inlet: Connect with the inlet hose from the water to the tub.
- Water Selector: Choose "WASH" for water supply during washing and rinsing, and "SPIN" for spin shower rinse.
- Soak Timer: Set the desired time for soaking, washing, or rinsing.
- Wash Program: This can be set to "Gentle", "Normal", "Strong", or "Heavy" based on the types and quantity of laundry.
- Drain Selector: Select "Wash Rinse" for washing and rinsing, and "Drain" to empty the tub of water.
- Spin Timer: Choose the desired time for spinning, with a maximum limit of 5 minutes.
```

(a)

```
Context:Arcelik Washing MachineUser's Manual 5083 FYE/5104 FYE
Your washing machine WASHING SPIN DRYER COVER COVER WATER SUPPLY SELECTOR a OVER FLOW o o SAFETY FILTER COVER: SPIN DRYER BASKET ROTATION 3 FILTER-C . ;
CABINET i PULSATOR POWER CORD @ VOLTAS
2.1 Overview
beko beko
“9 kg to 14 kg @ weteriiet ore cente seine or aman nese € aN a ~ Na )\ ME >, a on 7 r” a( ) VOLTAS -beko TD YSZ pwns watersetector sen @ Wash Timer Wash
Selector Drain elector Spin Taner off 9.01
1. Water Supply Inlet : Connect here with the inlet hose from the water to the tub.
2. Water Selector : Select “WASH” to supply water for washing and rinsing and “SPIN” for spin shower rinse.
3. Soak Timer : Select the desired time for soaking washing or rinsing.
4. Wash Program : Set the programe to “Gentle”, “Normal”, “Strong”, “Heavy” or Gentle, Normal, Strong, Heavy” according to kinds and quantity of the
laundry. ( “*” Applicable on 9 kg to 14 kg).
5. Drain Selector : Select “Wash Rinse” for washing and rinsing and “Drain” to drain the water out of the tub.
6. Spin Timer : Select the desired time for spinning. The maximum limit is 5 min. Don’t rotate the knob more than prescribed limit. WTT80, WTT85, WTT90 and
WTT14 models have turbodry with 10 minutes timer.
Makings on the product or the values stated in other documents supplied with the product are values obtained under laboratory conditions as per relevant
standards. These values may vary according to the usage of the appliance and ambient conditions.
Washing Machine / User Manual
Page number:  1
```

(b)

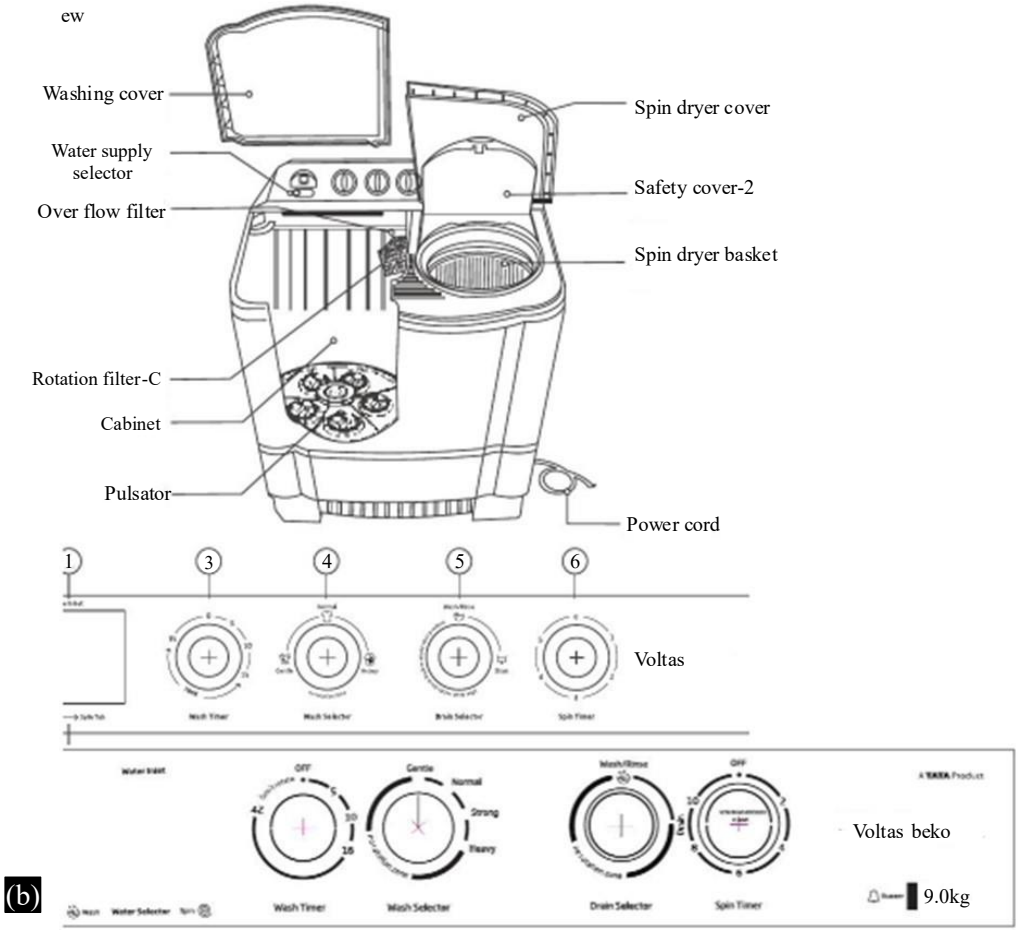


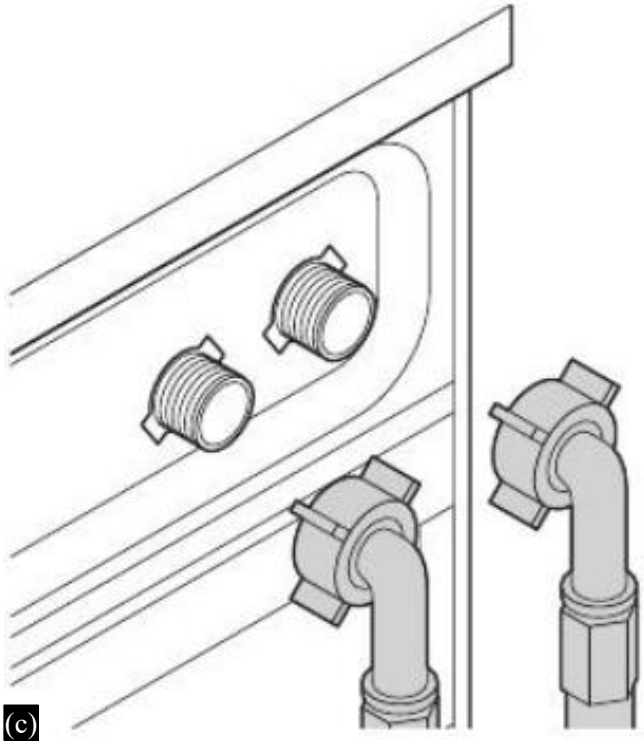
Figure 8. (a) Response to query 2 listing the various parts of the washing machine with detailed descriptions from the manual. (b) Contextual information related to query 2 providing additional details about the components. (c) Illustrating the parts of the washing machine.
(Image courtesy: BEKO, User's Manual Washing Machine: WTT75GT.)

```
Response: 1. Connect the special hoses supplied with the product to the water inlets on the product. Red hose (left) (max. 90 ºC) is for hot water inle
t, blue hose (right) (max. 25 ºC) is for cold water inlet.
2. Tighten all hose nuts by hand. Never use a wrench when tightening the nuts.
3. Open the taps completely after making the hose connection to check for water leaks at the connection points. If any leaks occur, turn off the tap and
remove the nut. Retighten the nut carefully after checking the seal. To prevent water leakages and damages caused by them, keep the taps closed when the
machine is not in use.
```

(a)

```
Context:

Connecting water supply
The water supply pressure required to run the product is between 1 to 10 bars (0.1 - 10 MPa). It is necessary to have 10 - 80 liters of water flowing from
the fully open tap in one minute to have your machine run smoothly. Attach a pressure reducing valve if water pressure is higher.
If you are going to use the double water-inlet product as a single (cold) water-inlet unit, you must install the supplied stopper to the hot water valve
before operating the product. (Applies for the products supplied with a blind stopper group.)
If you want to use both water inlets of the product, connect the hot water hose after removing the stopper and gasket group from the hot water valve.
(Applies for the products supplied with a blind stopper group.)
Models with a single water inlet should not be connected to the hot water tap. In such a case the laundry will get damaged or the product will switch to
protection mode and will not operate.

Do not use old or used water inlet hoses on the new product. It may cause stains on your laundry.
1. Connect the special hoses supplied with the product to the water inlets on the product. Red hose (left) (max. 90 ºC) is for hot water inlet, blue hose
(right) (max. 25 ºC) is for cold water inlet.
Page number:  2
-------------------------------------------------
Ensure that the cold and hot water connections are made correctly when installing the product. Otherwise, your laundry will come out hot at the end of the
washing process and wear out.
2. Tighten all hose nuts by hand. Never use a wrench when tightening the nuts.
3. Open the taps completely after making the hose connection to check for water leaks at the connection points. If any leaks occur, turn off the tap and
remove the nut. Retighten the nut carefully after checking the seal. To prevent water leakages and damages caused by them, keep the taps closed when the
machine is not in use.
Connecting to the drain
• The end of the drain hose must be directly connected to the wastewater drain or to the washbasin.
A Your house will be flooded if the
hose comes out of its housing during water discharge. Moreover, there is risk of scalding due to high washing temperatures! To prevent such situations and
to ensure smooth water intake and discharge of the machine, fix the end of the discharge hose tightly so that it cannot come out.
• The hose should be attached to a height of at least 40 cm, and 100 cm
Page number:  3
```

(b)



(c)

Figure 9. (a) Response to query 3 detailing the steps to connect the water supply hose.
(b) Contextual information related to query 3 providing additional guidance and notes.
(c) Images from the manual illustrating the connection of the water supply hose.
(Image courtesy: BEKO, Washing Machine User Manual: 5083 FY & 5104 FY.)

Maintenance and Repair Assistance

The application also supports routine maintenance and repair requests by offering clear, actionable instructions:

Query 4: "Describe the procedure for cleaning the fiber filters located on the interior surface of the loading door." The procedure for cleaning the fiber filters in query 4 is shown in Figure 10(a)–(c), presenting the response in Figure 10(a), the contextual information in Figure 10(b), and related images in Figure 10(c).

Automatic Product Identification from Barcode Images

In addition to handling text-based queries, the system automatically activates a dedicated barcode recognition module whenever the user inputs an image containing a barcode. This module leverages the DeepSeek Janus 7B model, which is specialized for image processing tasks, to extract key product details such as model number and brand.

This capability allows the application to quickly identify the product details without manual inputs. For example, when a barcode image is uploaded, the results of the product details are shown in Figure 11(a) and (b).

This categorization illustrates how the AI system delivers comprehensive, user-friendly support across the product lifecycle, from initial setup to aftermarket services, enhancing both user experience and appliance longevity, while maintaining the full traceability and transparency of the information provided. To evaluate the system's effectiveness, metrics such as answer relevancy, context precision, and context recall were applied. These measures help ensure that the responses, both text and images, accurately match the user's query, making the overall interaction clear, useful, and reliable for technicians in real-world scenarios.

Response: To clean the fibre filter:

• Open the loading door.

• Hold the first part (inner filter) of the two-part fibre filter and remove it by pulling it upwards.

• Remove the second part (outer filter) by pulling it upwards.

• Open both of the fibre filters (outer and inner) and remove the fibres with your hands or with the brush on the air deflector. You can clean the hai
r in the filters with a vacuum cleaner.

• Clean both filters under water running in the reverse direction of fibre accumulation or with a soft brush. Dry the filter before placing it back.

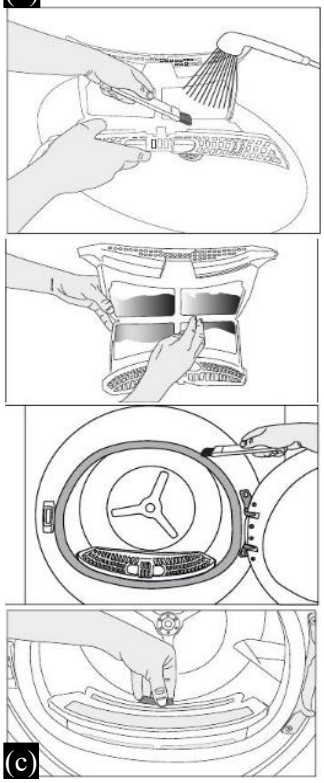
• Insert the fibre filters on one another and place it back in its place.

• Clean the inner surface of the loading door and the gasket with a soft damp cloth or the brush on the air deflector.

(a)

Context:
7 Maintenance and cleaning
Read the "Safety Instructions" first!
7.1 Fibre Filters (internal and external filters) / Cleaning of the Interior Surface of the Loading Door
The hair and fibres that are separated from the laundry during drying process is collected by the Fibre Filter.
After each drying cycle, clean the fibre filter and the inner surface of the loading door.
Your drying machine has 2 fibre NOTICE filters with one placed inside the other. Do not operate the product without the fibre filters.
To clean the fibre filter:
• Open the loading door.
• Hold the first part (inner filter) of the two part fibre filter and remove it by pulling it upwards.
• Remove the second part (outer filter) by pulling it upwards.
Dryer / User manual
Ensure that hair, fibre and cotton balls do not fall into the slot where the filters are installed.
• Open both of the fibre filters (outer and inner) and remove the fibres with your hands or with the brush on the air deflector. You can clean the hair in
the filters with a vacuum cleaner.
• Clean both filters under water running in reverse direction of fibre accumulation or with a soft brush. Dry the filter before placing it back.
• Insert the fibre filters on one another and place it back in its place.
• Clean the inner surface of the loading door and the gasket with a soft damp cloth or the brush on the air deflector.
7.2 Cleaning the sensor
The drying machine has humidity sensors that detect whether the laundry is dry.
To clean the sensors:
Open the drying machine loading door.
If the machine is hot due to drying operation, wait until it cools.
Clean the metal surfaces of the sensor with a soft cloth dampened with vinegar and then dry.
Clean the metal surfaces of the sensor 4 times a year. Do not use metal tools to clean the sensors' metal surfaces.
Due to fire and explosion hazard, do not use solutions, cleaning materials or similar tools to clean sensors.
Dryer / User manual

(b)



(c)

Figure 10. (a) Response to query 4 describing the procedure for cleaning the fiber filters located on the interior surface of the loading door. (b) Contextual information related to query 4 providing additional cleaning tips and precautions.
(c) Images illustrating the cleaning procedure of the fiber filters.
(Image courtesy: BEKO, Dryer User Manual: BDPB904HW/HG)

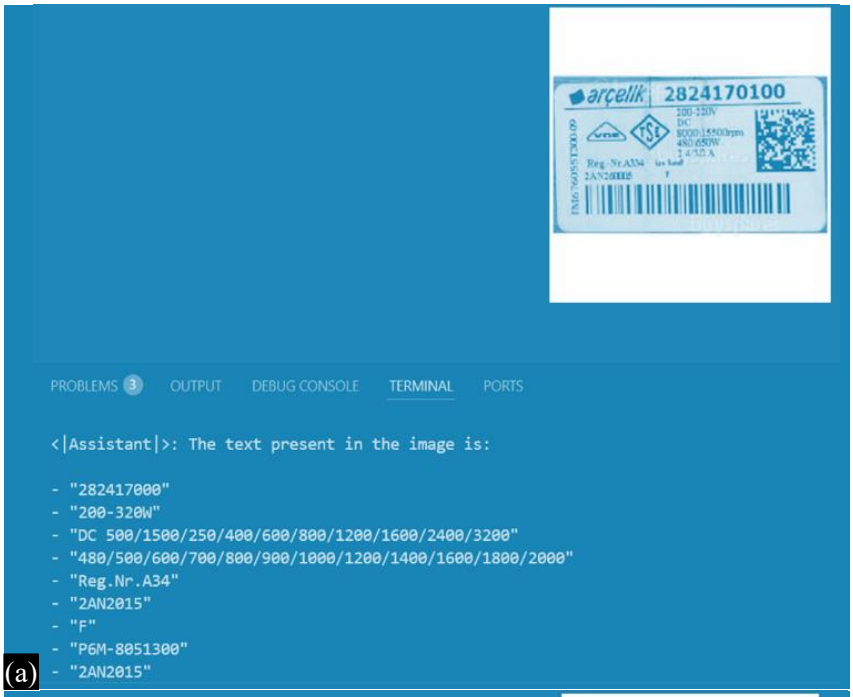


Figure 11. Automatic product identification from barcode images.

CONCLUSION

This solution demonstrates the effectiveness of integrating AI-based solutions, leveraging Neo4j for comprehensive data management and Multimodal Search with RAG for precise, contextually relevant instructions, the system significantly improves service delivery. Technicians benefit from detailed, accurate guidance that includes both textual and visual elements, leading to quicker resolutions, reduced errors, and higher customer satisfaction.

The evaluation metrics validate the system's performance, ensuring that the retrieved instructions and images are relevant and comprehensive. By addressing these areas, the solution aims to further refine the service experience, making it even more efficient and user-friendly for technicians and ultimately benefiting both consumers and businesses.

Future work will focus on further enhancing the AI capabilities and expanding the system's functionalities. Key areas for development include improving the LLMs/MLLMS to better understand and process complex queries and instructions from technicians. Enhance the multimodal search to include video tutorials and Augmented Reality (AR) guides for more interactive and intuitive support.

Optimizing the system for scalability to handle larger datasets and more concurrent users without compromising performance. Do it yourself (DIY) solutions will also be implemented together with the nearby store locators to procure the parts, thereby reducing the cost to consumers as well. Implementing a feedback mechanism for technicians to continuously improve the accuracy and relevance of the provided instructions based on real-world usage.

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