MR(Mixed Reality) Underground Utility Maintenance 
(Remote Collaboration) System
Development Background and Purpose

5G & MR Real-time Remote Collaboration System for Underground Utility

5G
(Hyper Speed & Connectivity)

- Enhanced On-site Response
- Multiple Connection Process
- Real-time Interaction
- High-speed Data Process
- High-capacity Data Transmit

Energy Management & Safety Prevention
- Real-time visualization of various underground util. info
- One-stop process for on-site accident prevention

Improvement of inspection & mgmt. process w/ tech.
- Real-time interaction technology coupled with 5G
- Enhanced inspection & management process

Test Bed & Infrastructure
- Smart-city verification project infrastructure
- Collaboration with spatial data business operator

MR
(Real Space + Augmentation + Virtual Info)

- Voice & Video Call
- Visualized Info
- 3D Object Tracking
- Substitution of Real Space Info
- Data Calculation

Daegu Suseong Alpha City
Visualization of Information
- Information database design & restriction
- Real-time 3D modeling algorithm design of management info
- Contents for visualization and display of data
- Application for mixed reality service

NFC Tagging
- NFC based info tagging and transmit system for underground utility management
- Acquisition of indicator coordinates management info and spatial mapping

Mixed Reality
- Application of mixed reality based "Air-tab" technology for remote collaboration
- Three-dimensional spatial recognition and camera tracking technology for underground utility maintenance
- Voice & Video call service through HMD

MR Underground Utility Maintenance System Flow
- BIM Data & Blueprint
- Extraction of Object Library
- Model Data Conversion
- MR Guide Platform
- MR Device Display Module
- Space & Object-data Merge
Current Services in Related Area

**Korea**

- ICT total-management-system with mixed reality technology applied to smart city development

  - IoT Based Monitoring & Mgmt.
  - Virtual 3D Spatial Info for Underground Facility
  - Augmented Spatial Info for Underground Facility
  - Work Orders through HoloLens

**Global**

- Underground pipe total-management-system with tunnel structure and monitoring sensors

  - Improve tracking error due to GPS through smart NFC converged with real-time 3D object rendering technology
    - Implementation of mixed reality based mobile application for underground utility can be difficult due to low-performing GPS
    - Interactive voice & video call technology by fully utilizing 5G communication
### Current Services in Related Area (Continued)

<table>
<thead>
<tr>
<th>Applied Field</th>
<th>Possible Applications</th>
<th>Other Possible Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>- Ship engine repair&lt;br&gt;- Plant maintenance&lt;br&gt;- Elevator maintenance</td>
<td>⟨ MR(Mixed Reality) Remote Assistance System ⟩</td>
</tr>
<tr>
<td>Assembly Guide</td>
<td>- Automobile parts assembly&lt;br&gt;- Airplane wiring and parts assembly&lt;br&gt;- Powertrain assembly</td>
<td>- Education</td>
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<tr>
<td>Remote Assistance</td>
<td>- Remote assistance with smart glass&lt;br&gt;- Electric wiring and maintenance&lt;br&gt;- Quality inspection</td>
<td>- Management</td>
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<tr>
<td>Automation</td>
<td>- Real-time remote control&lt;br&gt;- Production line&lt;br&gt;- Augmentation of factory data</td>
<td>- Public</td>
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</tbody>
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The diagram on the right illustrates areas such as Education, Management, Public, Manufacturing, and Disaster Prevention, where MR (Mixed Reality) technology can be applied.
Technology Development Summary

**Functions specialized in underground utility maintenance**
Buried pipeline monitoring service infrastructure w/ MR

**Augmented contents & HMD-linked platform**
5G based hyper-speed 3D object data transmission & output

**MR based underground utility monitoring system**
Smart mgmt. system w/ visualized info and remote assistance
<table>
<thead>
<tr>
<th>Cat.</th>
<th>No.</th>
<th>Functions</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Android</td>
<td>01</td>
<td>Obtain smart NFC based underground utility indicator info through NFC communication using an android device</td>
<td>MR</td>
<td>07</td>
<td>Confirm database of an area centered by the tagged NFC 3D positioning of underground utility info within the given area using latitude and longitude value</td>
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<td></td>
<td>02</td>
<td>Transmit underground utility info between android based device and HoloLense using bluetooth</td>
<td></td>
<td>08</td>
<td>Underground utility info dimensionalizing algorithm transmit targeted modeling data using managed code real-time processing of data into 3D modeling</td>
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<tr>
<td>HoloLense</td>
<td>03</td>
<td>Extract database sequence value from information obtained through HoloLense application</td>
<td></td>
<td>09</td>
<td>Display on to HMD : dimensionalized underground utility modeling objects based on tagged NFC coordinates</td>
</tr>
<tr>
<td></td>
<td>04</td>
<td>Confirm data by accessing underground utility database server with HoloLense application</td>
<td>5G</td>
<td>10</td>
<td>WebRTC based voice &amp; video call with designated control center within the area</td>
</tr>
<tr>
<td></td>
<td>05</td>
<td>Obtain full data within a given area from underground utility Database server using RestAPI</td>
<td></td>
<td>11</td>
<td>Information transmission of HMD user’s 1st person view and generated 3D modeling data of underground utility between the user and control center</td>
</tr>
<tr>
<td>5G</td>
<td>06</td>
<td>Access modeling data file server through 5G network and download targeted modeling data to HoloLense application</td>
<td></td>
<td>12</td>
<td>Remote assistance from control center</td>
</tr>
</tbody>
</table>
System Outline

AS-IS
- Buried pipeline work & inspection safety issue
- Work delay due to pipeline location confirmation lead-time
- Complex communication between control center and on-site worker

TO-BE
- Accident prevention through real-time information exchange
- Directly check with 3D objects
- Real-time on-site info exchange
- Expert consultation: Real-time remote assistance
- Confirm data after calculation process
- Visualized data through NFC tagging
- Smart Water Grid Application possible
System Functions

Smart NFC Based Underground Utility Mgmt, Info Tagging System

Smart NFC Indicator
Holds information on underground utility

Obtain pipeline data and prepare to transmit through NFC tagging

Android based NFC Tagging Device
Tag and mark information from Smart NFC Indicator

Transmit data obtained by Android based device to Windows equipped HMD through Bluetooth

MR HoloLens Device
Windows 10 equipped MR HMD

Smart NFC Based Underground Utility Mgmt, Info Tagging System

MR HoloLens Device
Windows 10 equipped MR HMD

Access pipeline DB based on tagged and transmitted info using Private Key

Buried Pipeline Database
Database and record of entire pipeline layouts in the area

Confirm and transmit tagged pipeline data to HMD based on positional value of a given area

5G hyper speed download of modeling files based on code value for MR output

Pipeline Modeling File Server
Holds information on pipeline modeling files by code

5G Process
System Functions (Continued)

Dimensionalization and Real-time 3D Modeling of Underground Utility Management Information

MR HoloLens Device
Windows 10 equipped MR HMD

Input collected pipeline data within a given area to MR application

Pipeline Info Process Algorithm
Process given pipeline data: Direction, connection, position, thickness, and etc.

MR display and visualize error based on data calculated by info processing algorithm

Augmentation Process

WebRTC Based Voice & Video Call Service

On-site User MR HoloLense
Underground Utility Info

Voice & Video Call with the control center through application
Transmit user’s 1st person MR view and request assistance

Remote assistance and guidance from control center

Control Center MR HoloLense
Control Center Info

5G Process
Dimensionalization and Real-time 3D Modeling of Underground Utility Management Information

**MR HoloLens Device**
- Windows 10 equipped MR HMD
- Input collected pipeline data within a given area to MR application
- Process given pipeline data: Direction, connection, position, thickness, and etc.
- MR display and visualize error based on data calculated by info processing algorithm

**WebRTC Based Voice & Video Call Service**
- On-site User MR HoloLens
- Voice & Video Call with the control center through application
- Transmit user's 1st person MR view and request assistance
- Remote assistance and guidance from control center

**Control Center MR HoloLens**
- Control Center Info

**Augmentation Process**

**5G Process**