SYSTEM ARCHITECTURE FOR CONTROL SYSTEMS VIA KNOWLEDGE LAYOUT SEARCH

Technical Field

[001] This disclosure relates to a complex system architecture and analytics engine for building, maintaining, and searching layouts for operation of control systems.

SUMMARY

[001a] According to a first aspect of the invention, there is provided a system comprising: a robotic apparatus; memory configured to store a resource model, the resource model comprising a mapping of a resource for management to a control state of the robotic apparatus configured to control an industrial process, the mapping comprising relationship data for the resource and the control state; sensor circuitry configured to capture control state data; communication interface circuitry configured to transmit control state update instructions to the robotic apparatus; and system control circuitry, in data communication with the memory and the communication interface circuitry, the system control circuitry configured to: receive, through the communication interface circuitry, a system control query associated with the robotic apparatus; reference the system control query against the resource model to generate contextual information and a search result for the system control query by comparing the system control query to descriptors of resources, relationship data, control states, or any combination thereof mapped within the resource model; via the communication interface circuitry, cause generation of an interactive display comprising the contextual information along with the search result; generate a prediction of an effect of submission of a control state update command on the industrial process responsive to the control state update command resulting from user interaction with the interactive display; via the communication interface circuitry, update the interactive display to include: an indication of the prediction; and a graphical prompt including an option to submit the control state update command to the robotic apparatus; create a first control state update instruction for the robotic apparatus responsive to selection of the option to submit; cause the communication interface circuitry to transmit the first control state update instruction to the robotic apparatus; after the first control state update instruction is transmitted, determine to iteratively correct the control state responsive to the selection of the option to submit and the control state data; create a second control state update instruction for the robotic apparatus responsive to determining to iteratively correct the control state; and cause the

communication interface circuitry to transmit the second control state update instruction to the robotic apparatus.

[001b] According to a second aspect of the invention, there is provided a method comprising: receiving a system control query associated with a robotic apparatus; referencing, using a processor, the system control query against a resource model to generate contextual information and a first search result for the system control query by comparing the system control query to descriptors of resources, relationship data, control states, or any combination thereof mapped within the resource model, where the resource model comprising a mapping of a resource for management to a control state of the robotic apparatus, the mapping comprising relationship data for the resource and the control state, the robotic apparatus configured to control an industrial process; via communication interface circuitry coupled to the processor, causing generation of an interactive display comprising the contextual information along with the first search result; causing the processor to generate a prediction of an effect of submission of a control state update command on the industrial process responsive to the control state update command resulting from user interaction with the interactive display; via the communication interface circuitry, updating the interactive display to include: an indication of the prediction; and a graphical prompt including an option to submit the control state update command to the robotic apparatus; creating, using the processor, a first control state update instruction for the robotic apparatus responsive to selection of the option to submit; transmitting, via the communication interface circuitry, the first control state update instruction to the robotic apparatus; and after the first control state update instruction is transmitted: receiving control state data via sensor circuitry; determining to iteratively correct the control state responsive to the selection of the option to submit and the control state data; generating a second control state update instruction for the robotic apparatus responsive to determining to iteratively correct the control state; and transmitting, via the communication interface circuitry, the second control state update instruction to the robotic apparatus.

[001c] According to a third aspect of the invention, there is provided a system comprising: memory configured to store a resource model, the resource model comprising a mapping of resources within multiple object storage databases, the mapping comprising relationship data to support access of the resources within the multiple object storage databases; communication interface circuitry configured to: access the resources in the multiple object storage databases in accord with the relationship data; transmit control state update instructions to a robotic apparatus; and system control circuitry, in data communication with the memory and the communication interface circuitry, the system control circuitry configured to: receive a system

control query associated with the robotic apparatus; reference the system control query against the resource model to generate contextual information and a search result for the system control query, the contextual information comprising: a selector tool for selection of a target control state; and an indicator of an initial control state; generate an interactive display comprising the contextual information along with the search result; determine the target control state for the robotic apparatus responsive to a user interaction with the selector tool; create a first control state update instruction for the robotic apparatus responsive to an initial difference between the target control state and the initial control state; cause the communication interface circuitry to transmit the first control state update instruction to the robotic apparatus; after transmission of the first control state update instruction, receive sensor data; reference the sensor data against the resource model to determine a current control state for the robotic apparatus; determine a current difference between the current control state and the target control state; create a second control state update instruction for the robotic apparatus responsive to the current difference; and cause the communication interface circuitry to transmit the second control state update instruction to the robotic apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[002] Figure 1 shows an example knowledge layout.

[003] Figure 2 shows layout manipulation logic (LML).

[004] Figure 3 show an example graph of an extension to an existing layout.

[005] Figure 4 shows example an example interactive contextual information display.

[006] Figure 5 shows an example knowledge layout.

[007] Figure 6 shows an example specific execution environment.

[008] Figure 7 shows example model onboarding by the LML.

[009] Figure 8 shows example instance logic for instantiation of a sub-layout.

[010] Figure 9 shows example instantiations of the physical model and the control and actuation system model.

[011] Figure 10 shows example query logic.

DETAILED DESCRIPTION

[012] Described below is a control system that may use knowledge graph based searches to generate system control query results. The system may receive system control queries generated by operator's search for resources related to actions or assets as part of a control system. The resources may be obtained from diverse locations associated to various logical and

hierarchical groupings with varying access rules and parameters. The knowledge layout may store relationship data such as keys, protocols, access indices, logical interpretation, other access parameters and rules within a mapping of the resources to control state outputs of the robotic control system.

[013] The sensor-actuator control system may control or monitor industrial actuation and sensor systems, individual actuators or sensors, portions of actuation or sensor systems, computer-controlled kinematic systems, electro-mechanical devices or other robotic apparatuses. For example, the knowledge layout may be used to access resources for evaluating the state (e.g..,

CLAIMS

1. A system comprising:

a robotic apparatus;

memory configured to store a resource model, the resource model comprising a mapping of a resource for management to a control state of the robotic apparatus configured to control an industrial process, the mapping comprising relationship data for the resource and the control state;

sensor circuitry configured to capture control state data;

communication interface circuitry configured to transmit control state update instructions to the robotic apparatus; and

system control circuitry, in data communication with the memory and the communication interface circuitry, the system control circuitry configured to:

receive, through the communication interface circuitry, a system control query associated with the robotic apparatus;

reference the system control query against the resource model to generate contextual information and a search result for the system control query by comparing the system control query to descriptors of resources, relationship data, control states, or any combination thereof mapped within the resource model;

via the communication interface circuitry, cause generation of an interactive display comprising the contextual information along with the search result;

generate a prediction of an effect of submission of a control state update command on the industrial process responsive to the control state update command resulting from user interaction with the interactive display;

via the communication interface circuitry, update the interactive display to include:

an indication of the prediction; and

a graphical prompt including an option to submit the control state update command to the robotic apparatus;

create a first control state update instruction for the robotic apparatus responsive to selection of the option to submit;

cause the communication interface circuitry to transmit the first control state update instruction to the robotic apparatus;

after the first control state update instruction is transmitted, determine to iteratively correct the control state responsive to the selection of the option to submit and the control state data;

create a second control state update instruction for the robotic apparatus responsive to determining to iteratively correct the control state; and

cause the communication interface circuitry to transmit the second control state update instruction to the robotic apparatus.

2. The system of claim 1, where the robotic apparatus comprises an actuator device.

3. The system of claim 1, where the robotic apparatus is configured to control fluid flow.

4. The system of claim 3, where the robotic apparatus comprises a portion of a control system for water circulation system.

5. The system of claim 1, where the contextual information comprises data collected from a first object storage database and a second object storage database.

6. The system of claim 5, where:

a first storage protocol for the first object storage database is different from a second storage protocol for the second object storage database; and

the system control circuitry is configured to obtain the contextual information by accessing the first object storage database in accord with the first storage protocol and accessing the second object storage database in accord with the second storage protocol.

7. The system of claim 6, where the interactive display is configured to present the contextual information without indication of the first and second storage protocols.

8. The system of claim 6, where the relationship data comprises a first indicator for the first storage protocol and a second indicator for the second storage protocol.

9. The system of claim 1, where the resource comprises a database location, a control command for the robotic apparatus, a control address for the robotic apparatus, or any combination thereof.

10. The system of claim 1, where the interactive display is generated using a touchscreen display, a movable cursor, graphical user interface, or any combination thereof.

11. A method comprising:

receiving a system control query associated with a robotic apparatus;

referencing, using a processor, the system control query against a resource model to generate contextual information and a first search result for the system control query by comparing the system control query to descriptors of resources, relationship data, control states, or any combination thereof mapped within the resource model,

where the resource model comprising a mapping of a resource for management to a control state of the robotic apparatus, the mapping comprising relationship data for the resource and the control state, the robotic apparatus configured to control an industrial process;

via communication interface circuitry coupled to the processor, causing generation of an interactive display comprising the contextual information along with the first search result;

causing the processor to generate a prediction of an effect of submission of a control state update command on the industrial process responsive to the control state update command resulting from user interaction with the interactive display;

via the communication interface circuitry, updating the interactive display to include:

an indication of the prediction; and

a graphical prompt including an option to submit the control state update command to the robotic apparatus;

creating, using the processor, a first control state update instruction for the robotic apparatus responsive to selection of the option to submit;

transmitting, via the communication interface circuitry, the first control state update instruction to the robotic apparatus; and

after the first control state update instruction is transmitted:

receiving control state data via sensor circuitry;

determining to iteratively correct the control state responsive to the selection of the option to submit and the control state data;

generating a second control state update instruction for the robotic apparatus responsive to determining to iteratively correct the control state; and

transmitting, via the communication interface circuitry, the second control state update instruction to the robotic apparatus.

12. The method of claim 11, further comprising compiling the contextual information from data available through the first search result and a second search result.

13. The method of claim 11, further comprising accessing the resource for management to generate the control state update instruction.

14. The method of claim 11, where the contextual information comprises first data collected from a first object storage database.

15. The method of claim 14, where the relationship data comprises an index for accessing the first data in the first object storage database.

16. The method of claim 11, where the user interaction comprises an adjustment of a target control state setting for the robotic apparatus; and

generating the second control state update instruction comprises generating a first series of control state update instructions to comply with the adjustment to the target control state setting.

17. The method of claim 16, further comprising generating a second series of control state update instructions to hold the control state of the robotic apparatus in accord with the target control state setting.

18. The method of claim 17, wherein the robotic apparatus comprises a multiple actuators in a water-utility flow control system; and

the target control state setting comprises a target flow setting, a target pressure setting, or both.

19. A system comprising:

memory configured to store a resource model, the resource model comprising a mapping of resources within multiple object storage databases, the mapping comprising relationship data to support access of the resources within the multiple object storage databases;

communication interface circuitry configured to:

access the resources in the multiple object storage databases in accord with the relationship data;

transmit control state update instructions to a robotic apparatus; and

system control circuitry, in data communication with the memory and the communication interface circuitry, the system control circuitry configured to:

receive a system control query associated with the robotic apparatus;

reference the system control query against the resource model to generate contextual information and a search result for the system control query, the contextual information comprising:

a selector tool for selection of a target control state; and

an indicator of an initial control state;

generate an interactive display comprising the contextual information along with the search result;

determine the target control state for the robotic apparatus responsive to a user interaction with the selector tool;

create a first control state update instruction for the robotic apparatus responsive to an initial difference between the target control state and the initial control state;

cause the communication interface circuitry to transmit the first control state update instruction to the robotic apparatus;

after transmission of the first control state update instruction, receive sensor data;

reference the sensor data against the resource model to determine a current control state for the robotic apparatus;

determine a current difference between the current control state and the target control state;

create a second control state update instruction for the robotic apparatus responsive to the current difference; and

cause the communication interface circuitry to transmit the second control state update instruction to the robotic apparatus.

20. The system of claim 19, where the system control circuitry is configured to determine the current difference between the current control state and the target control state by executing a genetic decision process configured to meet a constraint set via the selector tool.