Universitat De Girona

E-Health

Pacs and Visualization

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1 Introduction

DICOM network can be termed as the data network connecting DICOM compatible devices within a medical department. Usually, this network is a Local Area Network (LAN) and makes it suitable to connect PCs with dedicated DICOM compatible devices using special software's. Considering the kind and volume of data transmitted through this channel, many medical departments build sophisticated network to exchange administrative data and files. In this exercise, our goal are as follows to:

- Understand the basic architecture of a PACS system.
- Install and deploy a simulation of a PACS system using Orthanc software.
- Test and experiment with Orthanc's main functionality.
- Link a DICOM viewer (e.g. Gingko) to a DICOM server.
- Improve qualitative evaluation thanks to CT windowing.
- Digitally measure regions of interest.

2 Getting started with Orthanc

The following guide shows how the basic functionality of Orthanc (C-Echo, C-Store, C-Find, C-Move) has been carried out and tested. The environment setting used for the below tutorial consisted of 3 computers running on Windows 10 and connected to the same network (Figure 1).

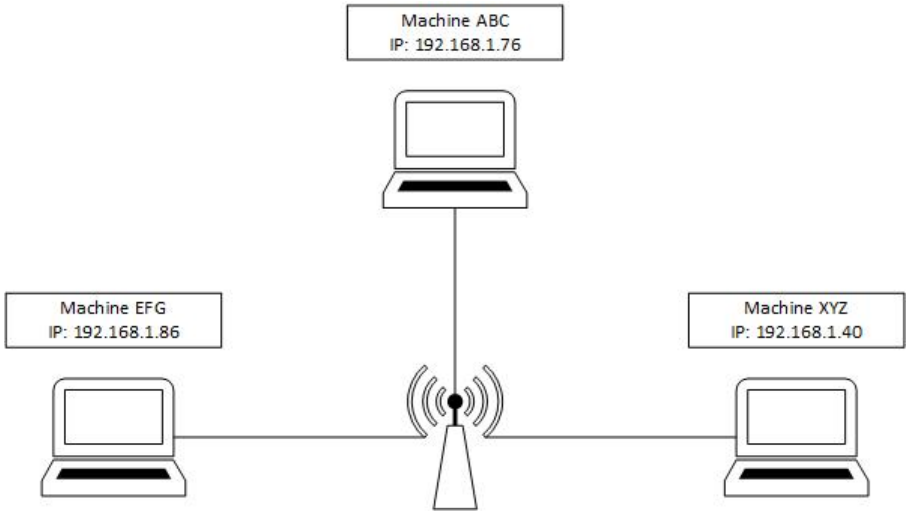
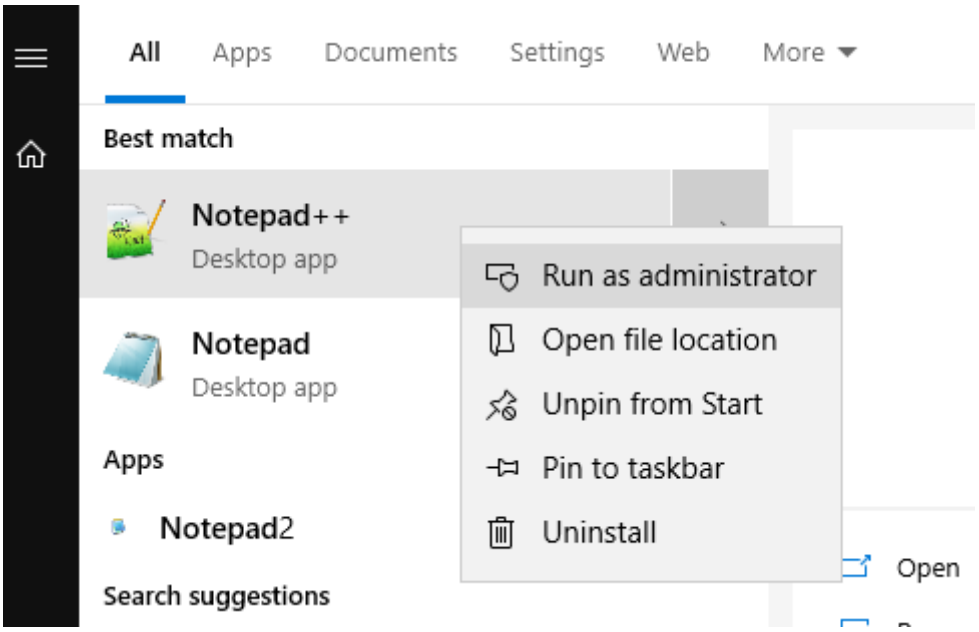


Figure 1: Hardware configuration for the experiment.

1. Install Orthanc from `https://www.orthanc-server.com/download.php`.
2. Edit the Orthanc's configuration file.

(a) Open a text editor with Admin privilege.



(b) From the text editor, navigate to the location where Orthanc is installed and, under the folder Configuration, open orthanc.json (e.g. `C:\Program Files\Orthanc Server\Configuration\orthanc.json`)

(c) Make the following changes:

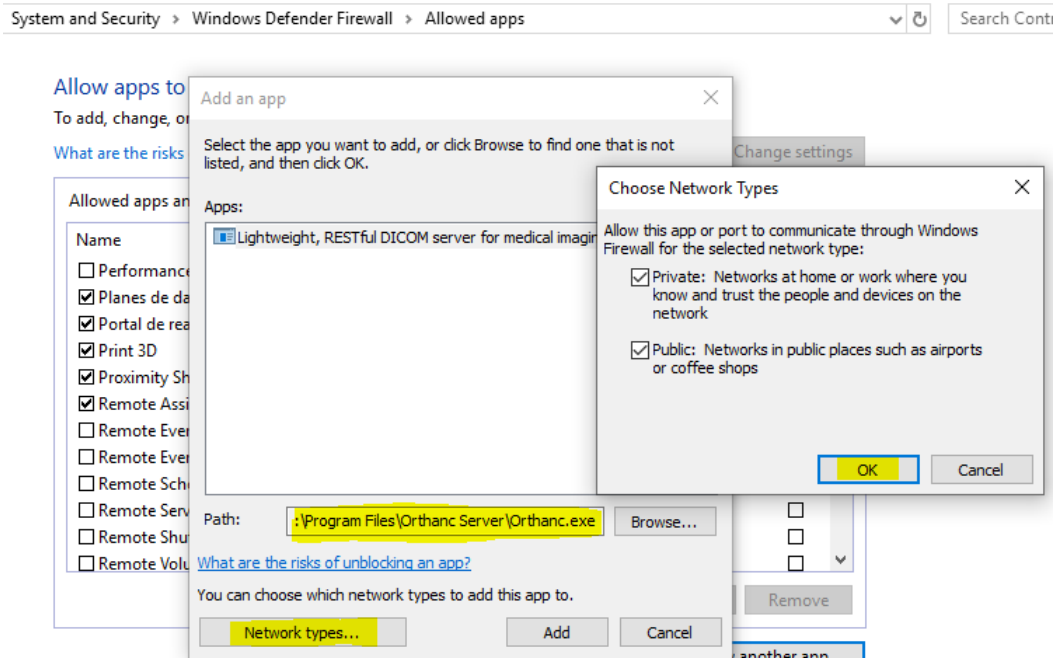
On machine ABC	On machine EFG	On machine XYZ
"DicomAet" : "PACS_ABC" "DicomPort" : 4242	"DicomAet" : "PACS_EFG" "DicomPort" : 4242	"DicomAet" : "PACS_XYZ" "DicomPort" : 4242

(d) Under the node "DicomModalities", add:

On machine ABC	"pacsEFG" : ["PACS_EFG", "192.168.1.86", 4242, "GenericNoUniversalWildcard"], "pacsXYZ" : ["PACS_XYZ", "192.168.1.40", 4242, "GenericNoUniversalWildcard"]
On machine EFG	"pacsABC" : ["PACS_ABC", "192.168.1.76", 4242, "GenericNoUniversalWildcard"], "pacsXYZ" : ["PACS_XYZ", "192.168.1.40", 4242, "GenericNoUniversalWildcard"]
On machine XYZ	"pacsABC" : ["PACS_ABC", "192.168.1.76", 4242, "GenericNoUniversalWildcard"], "pacsEFG" : ["PACS_EFG", "192.168.1.86", 4242, "GenericNoUniversalWildcard"]

(e) Save the file.

3. Add a rule in the firewall software running on the OS to allow the Orthanc application to communicate over the network.

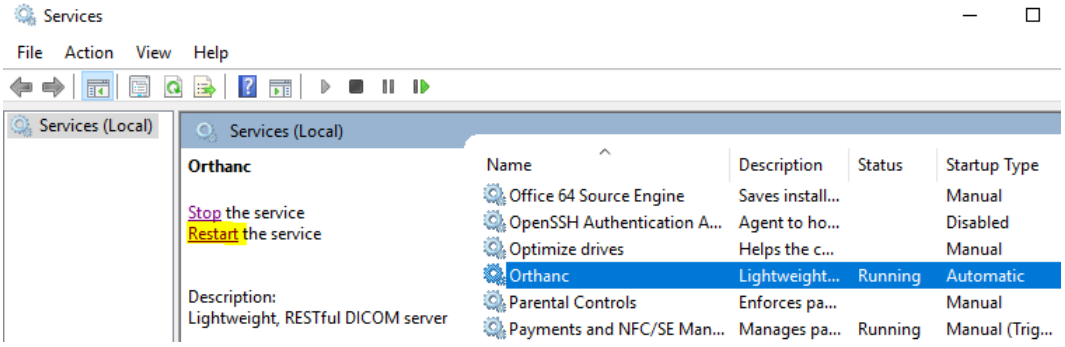


4. Restart Orthanc server.

(a) Press win + r to execute the "Run" application.

(b) Type "services.msc", and click OK.

(c) Search Orthanc in the list and click "Restart".



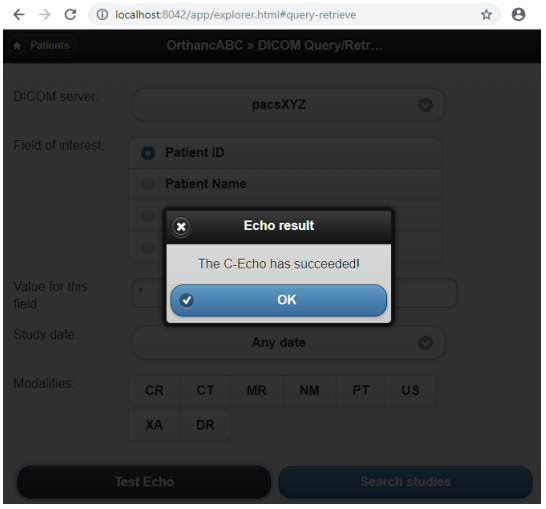
5. Open Orthanc explorer (i.e. Orthanc´s web interface) in the browser from `http://localhost:8042/app/explorer.html`

6. **(C-Echo)** Use Machine ABC to test the connectivity to Machine EFG and Machine XYZ.

(a) Click the "Query/Retrieve" button on the top-right.

(b) Under “DICOM server”, select “pacsEFG” or “pacsXYZ”.

(c) Click “Test Echo”.



7. **(C-Store)** Send DICOM images from Machine ABC to Machine XYZ.

(a) Under Orthanc Explorer homepage, click “Upload” button from the top bar.

(b) Drag and drop DICOM files.

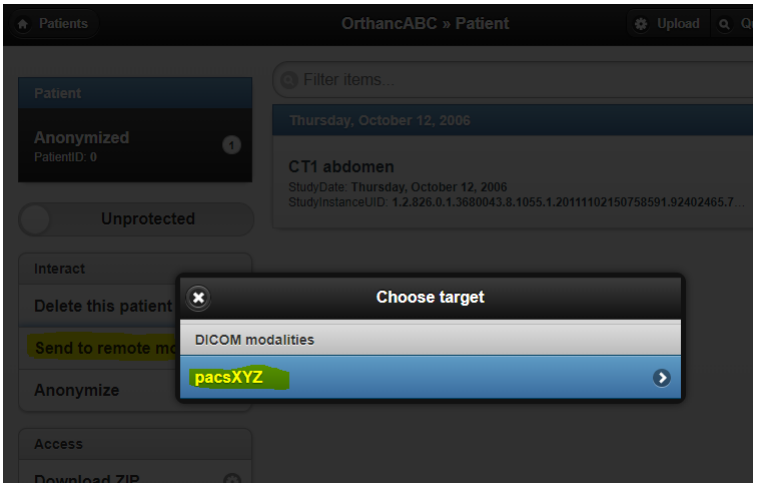
(c) Click “Start the upload”, and wait for the load to finish.

(d) Click on the “Patients” button from the top bar.

(e) Click on the newly added element in the list.

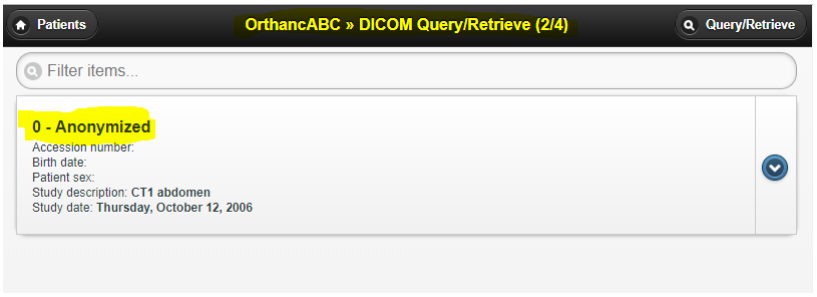
(f) Click “Send to remote modality”

(g) Select “pacsXYZ”



(h) Verify that the DICOM resource appears in Machine XYZ.

8. **(C-Find)** From Machine ABC, search DICOM resources on Machine XYZ.
   (a) Under Orthanc Explorer homepage, click "Query/Retrieve" button from the top bar.
   (b) Under "DICOM server", select "pacsXYZ".
   (c) Click "Search studies"; the result should appear in the list.



9. **(C-Move)** From Machine ABC, send DICOM resources available on Machine XYZ to Machine EFG.
   (a) From the previous step (8.c.), click on the blue down-arrow.
   (b) Under "Target AET", type "PACS_EFG" and click "Retrieve".
   (c) Verify that the DICOM resource appears in Machine EFG.

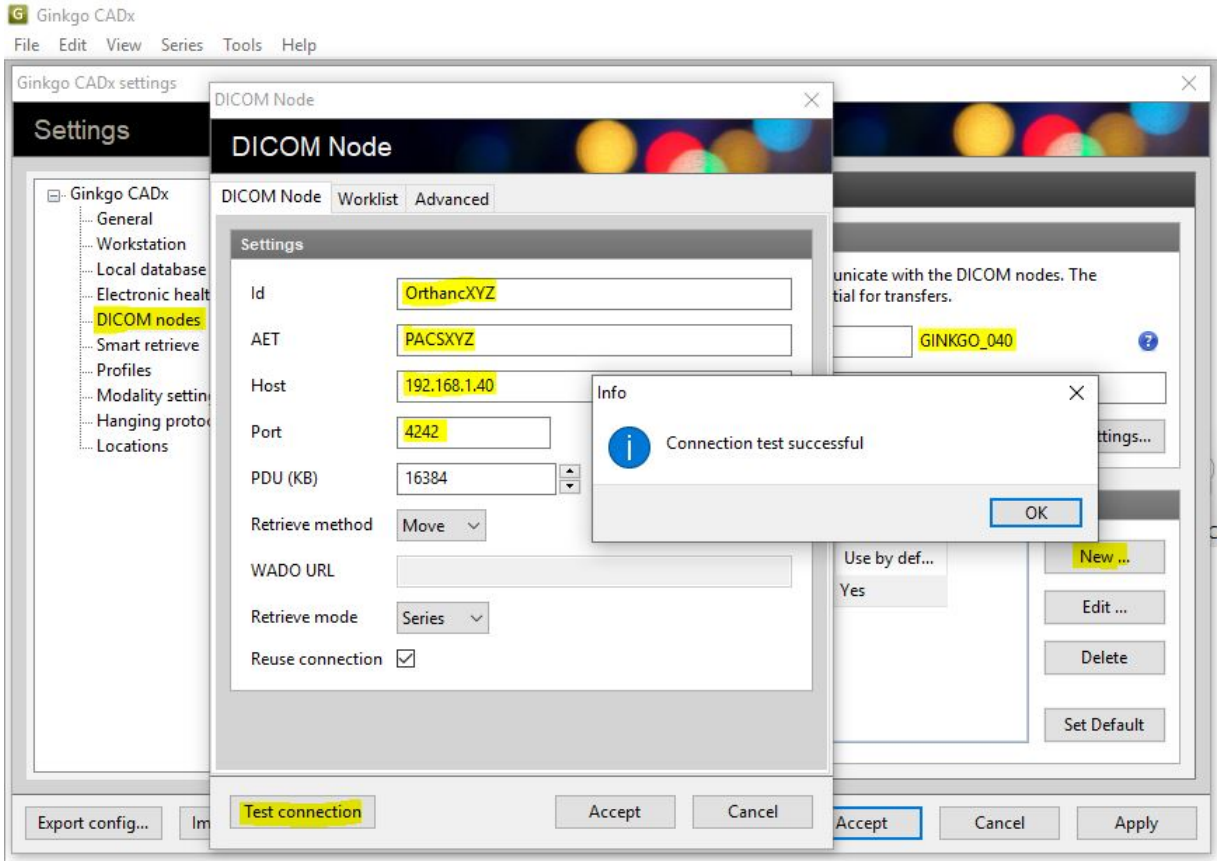
3 Ginkgo viewer

For our experiment, we successfully tested connecting Ginkgo on one machine to the Orthanc running on a second machine. For the sake of simplicity, we report here how the connection between the DICOM viewer (i.e. Ginkgo) and the DICOM server (i.e. Orthanc), both installed on Machine XYZ, was established.

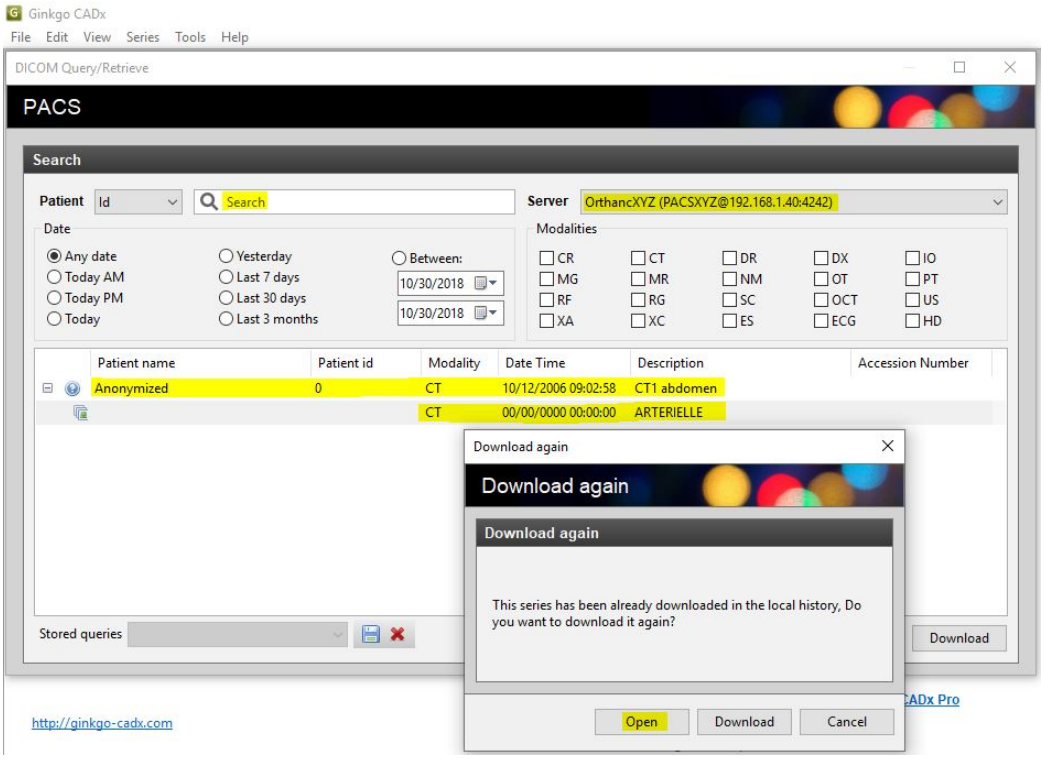
1. Ginkgo CADx viewer was installed from `http://ginkgo-cadx.com/en/`. We edited Orthanc's configuration file to add another entry to the "DicomModalities" object.:

   ```
   "ginkgoXYZ" : [ "GINKGO_040", "192.168.1.40", 11112,
   "GenericNoUniversalWildcard"]
   ```

2. Ginkgo viewer was configured to communicate with Orthanc.



3. In order to acquire and visualize DICOM series from PACSXYZ (i.e. the Orthanc server on Machine XYZ), we searched and opened the CT data using DICOM Query/Retrieve tool in the main menu.



4. The maximum contrast of the bones and soft tissue was done on the CT 25-slice with help of Ginkgo viewer tool named window/level (ctrl+W), see Figure 2.

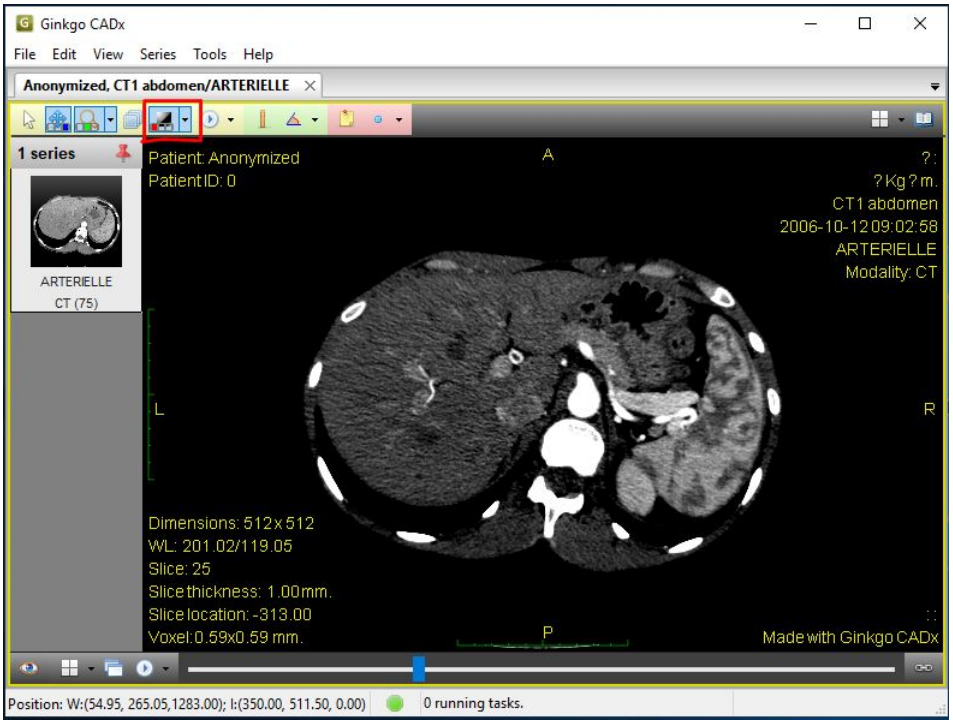


Figure 2: The maximum contrast of the bones and soft tissue

5. Figure 3 shows the measurement of the major axes of the vertebrae and ribs. This was done using the ruler tool (ctrl+R). The voxel/pixel size of the CT slice describes pixel size which is shown under the red line on the image characteristics.

Figure 3: The measurement of the major axes of the vertebrae and ribs

We can relate the length of an axis to the number of pixels multiplied by the pixel's size.

E.g.: In Figure 4, the identified extremity points of the axis are A (256.25,299.29) and B (314.76,317.70). The number of pixels along this axis is computed as:

$$numberofpixels = \sqrt{((317.70 - 299.29)^2 + (314.76 - 256.25)^2)} = 61.338 \quad (1)$$

Since the pixel spacing is 0.59 mm, then the length of the axis is 61.338 x 0.59 = 36.19 mm = 3.619 cm which is approximately the length found by the ruler tool (3.62 cm).

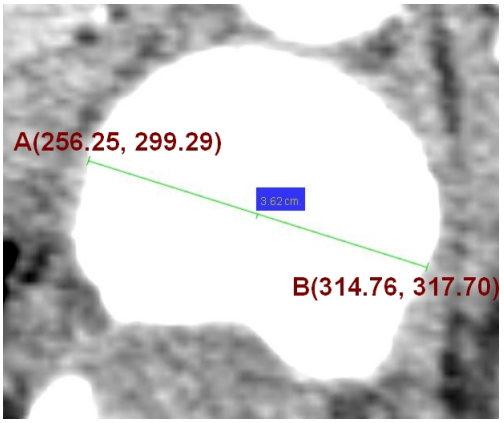


Figure 4: Example of measured distance

4 Issues

When working on this lab, we came across a few obstacles of varying degrees of difficulty but which we eventually overcame.

- **Saving the changes to the Orthanc configuration file (Easy)**
  The Orthanc configuration file is stored in a location (C:\Program Files) that is in read-only mode for non-admin users. That is, any modifications made to this file within an editor will not be possible to be saved. Opening the editor with Administrator privileges resolves the issue.
- **Unable to restart Orthanc server due to trailing commas (Easy)**
  The configuration file is in JSON format and JSON objects break when there is a trailing comma. We had one by inadvertence and the server would not restart. A quick look back into the latest modifications made to the configuration file helped us notice the trailing comma which we removed.
- **Allowing communication through the firewall (Easy)**
  Orthanc uses the port 4242 for the DICOM server. The port and application are not automatically allowed by the firewall software running on the machines. Instead of turning off the firewall, we added Orthanc to the firewall rules for allowing network communication.
- **Querying DICOM resources not supporting a wildcard (Moderate)**
  When searching for the patient or study available in a remote machine through C-Find, we were not getting the expected item in the result list. It was not clear at the beginning what the cause of the problem was. We have uploaded another DICOM resource and we were able to query it but not the DICOM data provided with lab. So we were suspecting that the query the web interface generates was not matching some characteristic of the DICOM data, especially that the interface allows to search by only one field (e.g. Patient ID, Patient Name, Study Description, etc.). We have then mimicked the job done by the web application when sending requests to the DICOM server by manually and systematically sending and processing AJAX requests with a modified payload (removing the wildcard characters from the form data); the test was successful and the wildcard was identified as the issue. We have also made the trick of modifying the query object from the JavaScript file "query-retrieve.js" and we were able to achieve the same result from the web application. However, soon after that, we realized that the configuration file enables adding the option "GenericNoUniversalWildcard" that replaces wildcards with empty strings for C-Find requests. Therefore, we have adopted this solution as it is the cleanest and in spirit with the intended way of tuning the Orthanc web application through the configuration file.