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1 Task Description

1.1 Introduction

The purpose of this course is to allow students to learn how to use and perform work in a real laboratory environment from distance. This means that the students must be able to perform any action that they could perform if they were physically in the laboratory, and also they should be able to use the existing laboratory equipment.

The work that will be taught and performed within this course is seam teaching and welding of a product. The seam that is to be detected will be of overlap type (Fig.1.1.1a), with two pieces of metal one over the other. The shape of the seam can vary; it can be circular like the one of Fig.1.1.1b, or any other shape. The welding of the product will be on the position of the detected seam for simplicity.

The detection and welding process will be performed with the use of an industrial robot. Additional tools will be used to allow the students to control the robot and the sensors as well as to be able to view any part of the laboratory and communicate with the teacher. A short list of the tool that are used is provided below, and an explanation of how to use these tools is given in the relative chapter.

The tools that are used are:
- SurfNet Breeze, for audio and video communication and virtual classroom
- Network cameras (Sony, Vivotek) and video systems (Axis)
- Seam Detection software (IntegLas), only sensor data will be provided to the students

![fig1](image1.png)

\[ a) \text{Overlap joint seam} \quad b) \text{Product with overlap seam} \]

Fig.1.1; Overlap joint definition and product
- Job Control software (24-Laser), allows to control the robot and prepare the welding jobs and paths
- Industrial Robot (Staubli RX130)
- Trumpf 4000 Laser
2 SurfNet Breeze

2.1 Introduction

Breese is a Macromedia internet application that is designed for video conferencing. This tool allows audio and video of the participants to be viewed and heard in the conference room by the use of a simple web-cam and microphone. In order for anyone to use Breeze they must set an account with SurfNet, which is the company that develops this application. Upon setting an account, the teacher must be provided with the data of the account, so that the student can be invited to participate to the CyberLab group and course.

2.2 Setting-up an account

To set up an account the following steps must be taken.

a) Visit https://www.surfgroepen.nl/signup/default.aspx, an activation email will be sent to you at the email address that you will provide. Upon receiving of the activation email, follow the instructions on the email in order to activate your SurfNet account.

b) As soon as the account is set, send an email with your name and the email address that you used to set an account in SurfNet to your teacher.

c) When you teacher adds you in the CyberLab group, you will get an invitation email with a link to the CyberLab’s group web site.

d) At that site there is the logo which is displayed in Fig.2.2.1. By clicking on this logo you start the Breeze application.

Fig.2.2.1: Breeze application logo/button
2.3 Description of Breeze

After clicking on the logo of Breeze in the CyberLab group web site, a new window will appear which will request your login data of your SurfNet account (Fig.2.3.1). By filling the correct data, you can enter the Breeze application. As was mentioned before, Breeze is a Macromedia based application, so it could be the case that the system asks you to allow it to install some additional software.

Breeze, has a variety of tools that can be used for video conferencing. Nevertheless, only the required items for this course will be explained. Students are free to experiment with the rest of the Breeze tools, but not during the time of the course.

a) Starting View

Upon login, a screen similar to the one of Fig.2.3.2 will appear. The several parts will be explained in the following paragraphs.

![Breeze login page](Fig.2.3.1: Breeze login page)

![Breeze application](Fig.2.3.2: Breeze application)
b) Camera and Voice window

In order for a participant to be able to talk to and be seen by the other participants, he/she has to activate the camera and voice window (Fig.2.3.3). This can be easily done by pressing the “start my camera and voice” button on the bottom left corner of the Camera and Voice window.

![Camera and Voice window](image)

Fig.2.3.3: Camera and Voice window

As soon as the “start my camera and voice” button is pressed, a new window from the “Macromedia Flash Players Settings” will pop up which will ask for permission to “Allow surfgroepen.nl to access your camera and Microphone”. This action must be allowed by selection the “Allow” button on that window. Then the Camera and Voice window will change to the one of Fig.2.3.4

![Activated Camera and Voice window](image)

Fig.2.3.4: Activated Camera and Voice window

When a participant wants to talk, the talk button must be clicked. By pressing the small lock icon next to the talk button, allows the participant to talk without having to keep the mouse on the “Talk” button. With the camera button the participant can allow the other member to see his video images or not. When a member does not have a webcam or he does not want to be viewed. The image of Fig.2.3.4 appears on the window. In any other case the images of the webcams appear. All the participant images are tilled next to each other with their names right underneath
them. When a participant talks, a green bar indicating the voice level appears over the name of the participant in the Camera and Voice window.

c) Attendee List window

The attendee list window (Fig.2.3.5) is the window where all the participants and their names are displayed.

![Attendee List window](image)

*Fig.2.3.5: Attendee List window*

d) Chat window

In the chat window (Fig.2.3.6) the participants can post questions and communicate with only certain members of the meeting.

![Chat window](image)

*Fig.2.3.6: The Chat window*
e) Note window

The note window (Fig.2.3.7), is a simple text editor where notes can be kept.

![Fig.2.3.7: The Note window](image)

f) Whiteboard and Presentation

Certain members can be allowed to share power point presentations in the share window. The share window is the main window of the Breeze application. When a presenter is using the presentation tool, the presentation slides appear on the share window in the same manner as if it was on a presentation room. The whiteboard option of Breeze allows the participants to draw sketches on a virtual whiteboard.

2.4 Sharing Applications

Breeze allows the members to share windows and applications. This means that members from remote computers can use and change the parameters on a shared application. This tool will be used in the context of this course only from the side of the teacher. This will be necessary when robot movements and seam teaching will be performed, so that the teacher can allow the students to control and manipulate the robot from their own computer.

The application that is going to be shared during this course is 24-Laser. The functionality of 24-Laser is described in chapter 4. When the teacher shares an application, the image of this application appears on each of the members Share window. To be able to take control of the application you have to request control from the teacher. This can be done by selecting the “Request Control” button on the top right corner of the Share window. Once the request has been approved by the teacher, it is possible for the student to change the parameters of the application. It is important to understand when the students take control of the application, their actions are immediately executed. For this reason they must always request the approval from the teacher, before enabling the robot to move. The teacher has the ability to stop the access of control to the application when he finds necessary.
3.1 Introduction

Important parameter for the correct implementation of this course is the use of the several network cameras and video server. There are two network cameras and one video server. The network cameras (Sony, Vivotek) have the ability to tilt/pan/zoom, and are controllable from a web page. The Vivotek camera has the ability to also transmit sound over IP. The video server (Axis) has four input video channels which are displayed on its separate web site. More information on the use of these tools are presented in the following paragraphs.

3.2 Sony

To connect to the Sony camera at the robot cell of the University of Twente the following IP address http://130.89.66.191/ must be followed from and internet browser application. The web page of Fig.3.2.1 will appear. The camera can be interfaced to the internet in two ways, either by Java or by ActiveX. The students are recommended to use the ActiveX version, as it allows additional control of the camera. Upon selection to proceed further, an authorization code will be requested. Use the one that is provided to you by the teacher/administrator. When ActiveX is selected for controlling the camera, additional software will be installed on the participants’ computer by the camera. Without this software there will be no video streaming.
When the authorization data is accepted a web page similar of Fig.3.2.2 appears.

On the top there are a number of control icons that are presented in Fig.3.2.3.

The Control icon brings up a virtual remote control that allows the used to move the camera around and zoom in several parts of the view. More detailed description will
be given in the following paragraphs. The Capture icon captures an image of the
current view and displays it in a new window. The user can then save that image by
right clicking on it and selecting “Save Image As…” from the appearing pop-up
menu. The Trigger and Settings icons are accessible only from the Administrator,
and the Home icon brings the user in the initial homepage of the camera.

On the top left side of the Sony website exists the two pop-up lists that are shown in
the following Fig.3.2.4. The first one is responsible for the rate at which the frames
are being refreshed on the web site, whereas the other is responsible for the size
that the image when it is displayed. Slower connections should request smaller
image display sizes.

![Fig.3.2.4: Frame rate and View size pop-ups](image)

When the control button is pressed a virtual remote control appears on the left side
of the web site that looks like Fig.3.2.5a and a zoom bar appears under the video
frame like the one of Fig.3.2.5b.

![a) Remote control](image) ![b) Zooming bar](image)

*Fig.3.2.5: Camera position and zooming tools connected to the Control icon*

The functionality of these controls is straight forward. The arrows of the remote
control allow the movement of the camera towards the required direction. The
decreasing number among the arrow buttons is the time left for the user to control
the camera. If there is no number on the remote control, then the user has unlimited
time. The Wide and Tele buttons zoom out of and in to the image. And the pop-up
list box allows the used to move the camera to predefined positions. These positions
re defined by the administrator. By clicking on the corners of the zoom bar, the
camera zooms in and out to the maximum. When the user selects a place on the zoom bar, then the camera zooms at an amount that is relative to its distance from the outer limits on the zoom bar.

Alternative ways to control the position and zooming of the camera make use the actual image and the use of the mouse cursor, and they can be summed up in the following:
- Clicking on any position one the video image moves the camera in such a way that that point becomes the center of the new image.
- Zooming on the image can be achieved by selecting an area on the image that is to be zoomed in. To achieve this, the user must click and hold the mouse button pressed while moving the cursor. A red square will begin to worm from the initial position of the cursor to the current position of the cursor. This red square includes the area that is going to be zoomed in. By releasing the mouse button the zooming action is initiated. Additionally the camera moves to bring the area of the red square in the middle of the image.

3.3 Vivotek

To connect to the Vivotek camera at the robot cell of the University of Twente the following IP address [http://130.89.66.205:81/](http://130.89.66.205:81/) must be followed from an internet browser application. The web page of Fig.3.3.1 will appear. This camera requires authorization to view it contents and control it. Use the authorization data that is provided to you by the teacher/administrator. This camera also requires that additional ActiveX components are installed on the user’s computer. Therefore, if not installed, the camera will request to be allowed to install those components.

![Fig.3.3.1: Vivotek camera starting web page](image)

The Vivotek camera has a variety of tools that allow the user to control the camera, and additionally it allows the user to transmit and receive voice over the internet in real time.
The first set of tools appears on the left top part of the website (Fig.3.3.2). This is the tilt and pan remote control of the camera. With the use of the arrows the camera can rotate towards the desired direction. The home icon in the middle of the arrows brings the camera to its home position. Underneath the arrow button exists a pop-up drop list with preset positions. By selecting an element from this list the camera moves its view towards a preset position. These presets can only be set by the administrator. The last part of this group of controls is the speed settings. The user can select how fast, or how big the movements of the camera should be along its tilt and pan axis, as well as how much the zooming action should increase or decrease on every step.

![Pan and tilt controls](image1)

**Fig.3.3.2: Pan and tilt controls**

The second set of control tools have to do with the manual control of the lens and imaging settings (Fig.3.3.3). This means that the user is allowed to control the zooming action in the image as well as the focusing distance and the opening of the iris.

![Lens controls](image2)

**Fig.3.3.3: Lens controls**

The third set of controls involved the manipulation of the settings (Fig.3.3.4). From this set of buttons the most important for this course is the Snapshot button. This button allows the user to grab an image of the current view of the camera.
The fourth and one of the most important tools of the Vivotek camera is the sound (Fig.3.3.5). The first button of this group is the only one which is not related to sound, and it is the one that enables or disables the digital zoom function of the camera. The second button is the one that allows the voice from the user’s side to reach the camera. When pressed, everything that the website user says can be heard from the speakers connected to the camera. The same button also disengages the transmission of sound towards the camera. The final two buttons with the loud speaker and the microphone, determine the powers of the sound that is reproduced on the user’s computer and the power of the sound that it is transmitted by the user’s microphone towards the camera. If the mute option on the loud speaker is selected, then no sound is received from the camera, and if the mute option is selected for the microphone, no sound is transmitted towards the camera.

![Sound and digital zoom controls](Fig.3.3.5: Sound and digital zoom controls)

### 3.4 Axis Video Server

The Axis video server allows the view of several video streams on the same website. To connect to the video server at the robot cell of the University of Twente the following IP address [http://130.89.66.205/view/index.shtml](http://130.89.66.205/view/index.shtml) must be followed from an internet browser application. This server also requires authorization to view it contents. Student can use the authorization data that will be provided to them by their teacher/administrator. Upon login, a web page similar to the one of Fig.3.4.1 will appear. The view is split into four different parts:

- **Top Left:** Sony Camera view
- **Top Right:** Vivotek Camera view
- **Bottom Left:** Coaxial view to the welding process through the welding head
- **Bottom Right:** The monitor view of the teacher’s computer

On the top part of the website, there is the control menu of Fig.3.4.2. This menu is straightforward. The first part is the size of the images. The Second is the video format (should not be changed if the current setting works on user’s computer). The third part is the Source. With the source the user can select to view only one of the four images instead of all four. This is a very useful tool, in the case where one of the images needs to be studied in more detail. And the fourth part is the Snapshot button which makes a picture of the current view in the website.
On the bottom part of the website the control buttons of Fig.3.4.3 are present. From these buttons the most important is the first button on the right. This button allows the current videos to be played in full screen view on the computer’s monitor.
4 Robotics and 24-Laser

4.1 Introduction to Robots

The robot that is used for the purposes of this course is a Staubli RX-130 six degrees of freedom industrial robotic arm (Fig.4.1.1). There are various ways to make the robot move from one point to another. For the requirements of this course, all movements will be implemented in relation to the working point of the laser tool which is attached to the robot. If can be seen in Fig.4.1.1, that the tool working point is at the laser focus point. The point is called the Tool Center Point and the abbreviation TCP will be used for it in the rest of the text. Additional to the position of the TCP the orientation of the coordinate system of the tool is also required. The orientation of the laser tool is also displayed in Fig.4.1.1.
There are a number of calibrations that need to be performed to be able to accurately define the TCP of the laser tool in respect to the end flange of the robot. These calibrations fall out of the scope of this course and therefore will not be explained.

4.2 Introduction to 24-Laser

24-Laser is a software tool that has been developed by the group of Mechanical Automation of University of Twente to assist in the controlling of robots and their integration to different sensors and equipment. This tool has a variety of capabilities, but only the ones required in this course will be described in this text. At start up, the main window of the application is presented in Fig.4.2.1.

![Fig.4.2.1: Main window of 24-Laser application](image-url)
From the main window the connection status with the robot and the sensors can be viewed and altered. Additionally, the definition of paths and trajectories that the robot has to follow can be set within this window. This allows the easy preparation of robot jobs, to be processed toward the later stage of laser welding.

**a) Robot Status and Control window**

This is the window that allows the manipulation of the robot movements (Fig.4.2.2). It can be selected from the menu Robot->Show Control. The most important parts of this window are the robot connection and enabling controls and the robot movement controls.

![Robot Status and Control window](image-url)
On the top left part of the window there is a pop-up drop list from where the name of the robots available to be connected appears. When a robot is selected, the “Connect” button can be pressed to complete the request (this part will be performed by the teacher). Upon connection with the robot, the buttons on the top right side of the window will become enabled. Most of the buttons and bullets on this group are providing information about the status of the movement. The most important button is the “Unpowered” button. For the robot to perform any movement, it has to be powered. By pressing the “Unpowered” button, the robot is commanded to be ready for execution of movement commands. Then, the “Unpowered” button is renamed to “Powered” and gets a green color.

To move the robot, from the Motion Group tabs, we have to select the one named “Cartesian”, because we want to move the robot according the Cartesian coordinates of the laser tool Fig.4.2.3. It is important for the laser tool name to be selected on the “Tool” pop-up drop-down list on the left bottom corner of the window. Still this is something that the teacher is responsible for. On the right part of the tab presented in Fig.4.2.3, the user can ask the robot to move and rotate relative to its current location. The movement length in mm and rotation in degrees can also be set. Note that the “Tool” option is selected on the drop-down list to inform the robot to move according to the selected tool’s coordinate system. **When a student wants to move the robot, must ALWAYS ask for permission from the teacher before he/she does so.**

![Fig.4.2.3: Robot Cartesian move tab](image)

**b) Sensor Control window**

This is the window that allows the connection to several sensors (Fig.4.2.4). It also contains a drop-down list with the names of the available sensor for connection. For the purposed of this course this value is set in “Localhost“ because the software of the sensor is executed in the same computer as the 24-Laser application. When the sensor is connected, its current transmitted data is displayed at the “Sensor Values” line. This is also performed by the teacher.
c) Equipment Control window

This is the window that allows the connection to several other equipment (Fig.4.2.5). From this window the user can manipulate the flow of Crossjet, Processgas, etc. For the requirements of this course, the students will be able to turn on and off the crossjet. The crossjet is a flow of air that prevents process spatter and gasses to reach and pollute the laser focus lens.

d) Laser Control window

This is the window that allows the user to control the laser power of the process at hand (Fig.4.2.6). It also gives an overview of the laser equipment status. For the
purposes if this course only the “Claim Laser” button is important. This button allows the robot working cell to use the laser.

Fig. 4.2.6: The Laser Control window
5.1 Seam Teaching

For seam teaching an optical triangulation sensor similar to the one of Fig.5.1.1 is used. These sensors are able to provide information about the position and orientation of the seam, when it is placed within their field of view. In Fig.5.1.1, three of these sensors are at work, projecting a structured light shape around the tool’s TCP.

![Fig.5.1.1: Example of triangulation structured light seam detection set-up](image)

These types of sensors usually provide 4 to 6 measurement data. Those data are always the xyz position measurements of the seam in relation to the sensor and one to three of the rotations of the seam in relation to the sensor. For the sensor data to be useful to the laser tool, extra calibrations are required to determine the transformation from the sensor coordinate system to the laser tool coordinate system. These calibrations do not fall in the subject of this course and therefore will not be explained further.
Before the seam teaching process can be performed, the seam detection sensor has to be placed at the beginning of the seam. The sensor functionality is outside the scope of this course. For better determination of the correct position of the sensor, live images of the sensor’s output (Fig.5.1.2) will be available on the video server website. The red lines show the detected parts of the structured light and the breakpoint is the position of the seam (for overlapped joints).

When the sensor is placed in the beginning of the seam a new path must be created in the 24-laser main window. The steps to create a new path are the following:

- Right click in the path list and select “New Path” from the pop-up menu
- Enter a name for the via (e.g. Taught_path)
- Right click on the name of the newly created path on the list, and from the pop-up menu select “Seam-teaching”
- The window of Fig.5.1.3 appears

The top group of the window in Fig.5.1.3 displays information about the sensor that is used for the seam teaching, the frame accosting to which the sensor measures and the speed that the sensor moves from one point to the other.

The second group of the window in Fig.5.1.3 contains the seam teaching parameters. These parameters include:

- The algorithm that is used for the fitting and the estimation of the direction that the sensor has to move
- The step size in mm, which is the distance that the sensor has to move until it makes another measurement
- The remaining edit spaces change names depending on the teaching algorithm that is used. Their values should not be changed unless instructed by the teacher.
The third group of the window in Fig.5.1.3 contains the control to teach the trajectory. When a sensor is connected to 24-Laser, the user is allowed to:

- “Teach Location”, imports the current location of the sensor to the path
- “Teach and Move”, imports the current location of the sensor to the path and moves to the next position
- “Line Move to Start”, moves the sensor to the first position of the path
- “Replay Path”, replays all the taught points of the path
- “Plot”, displays a plot diagram of the taught points
- “Save->File”, saves the path to a file

During this course the function that is going to be used mainly for teaching is the “Teach and Move”. After having placed the sensor on the beginning of the seam, we can teach points in the path by pressing the “Teach and Move” button. When the
sensor reaches the end of the seam, the path can be concluded by pressing the “Add Path” button at the bottom right corner of the window in Fig.4.1.3. When the application returns to the main window of 24-Laser, by clicking on the taught path, the user can see a list of all the taught points.

Before a student attempts to move the robot for teaching, must **ALWAYS** ask for permission from the teacher.

The fourth group of the window in Fig.5.1.3 contains the controls for automatic teaching of the seam. This is an autonomous function which is mainly for simple paths. This function does not fall in the scope of this course, and will not be explained further.

### 5.2 Job Preparation and Welding

The next step after teaching the seam is to prepare a job for laser welding. This means that we need to provide the Robot with a starting point away from the seam, then a starting point near the seam, the points of the seam trajectory that need to be followed, and an ending point away from the seam.

The points that the robot has to pass from and do not belong to a trajectory where a work is performed are called “via’s”. This means that the Start Point and End Point are via’s and can be set in the 24-Laser main window “Via’s” group. The steps to set a via are the following:

- Right click in the via list and select “New via” from the pop-up menu
- Enter a name for the via (e.g. Start)
- Double click on the name of the newly created via on the list
- The window of Fig.5.2.1 appears

![Fig.5.2.1: Via Editor window](image-url)
By pressing the “Custom loc” button a new dialog will appear where the user can import the three positions (x, y, z) and three orientations (rx, ry, rz). Still, this option should be used only if the location of the via is free of any obstacles that could cause collision. The best way to set the starting and ending via’s is by obtaining the first and the last points of the working trajectory and copy them as via’s with an increased z position value.

The “Current Tool loc” button returns the current position of the tool which can also be edited to become a via. After pressing the current tool location button, select the newly formed via from the list and press the “Edit Location” button. This will open a dialog where all the positions and orientations of the via appear for further editing.

After finalizing the parameters of the via, the Via Editor window can be closed.

**When setting a via **ALWAYS** ask for the help of the teacher before it is placed in a job.**

After having set all the required via’s the path group of the 24-Laser main window should be similar to the one of Fig.5.2.2. At the paths list there is the path that was taught with the seam detection sensor, and there are also two via’s for the start and the end of the job.

![Fig.5.2.2: View of a simple path and its via’s](image)

The green arrows of Fig.5.2.2 transfer the selected via or path to the job list. The via’s and paths of the job list are being executed according the order that they are placed. Therefore special care has to be taken at the placement of the via’s with the relative path. For the current example of Fig.5.2.2, the following order should be followed:

- Select via “Start” and place is to the job with the green button. This is the initial position of the tool.
- Select path “Taught_path” and place it into the job. The tool moves to its trajectory start point and performs the requested job.
- Select via “End” and place is to the job. The tool moves away to the ending via
- Select via “Start” and place is to the job. The tool moves to the initial start point to be ready for next run.
At the end of this process the job list should be similar to Fig.5.2.3.

![Job](image)

**Fig.5.2.3: Defined job**

Now that the job is prepared, there is need to assign the laser power that the welding will be performed on each of the paths. This can be implemented with the following steps:

- Double click on the path to open its contents
- On the top left corner of the path window press the button “Edit Equipment”
- The dialog of Fig.5.2.4 appears

![Edit Global Path Equipment options](image)

**Fig.5.2.4: Edit global path equipment dialog**
- Check the “Use Laser” option
- Determine the required laser power for the job with the use of the table in Appendix C and the data provided by the teacher
- And fill in the required laser power in the “Laser Power” edit box.
- If it is required to use crossjet then select this option
- Press “Apply”

When the focus is returned on the path window, all the points in the path will have the laser option checked and the laser power set to the value that was selected.

The final step that remains is to test and run the job. This can be implemented with the help of the dialog that is being displayed in Fig. 5.2.5. To open this dialog, select “Process Job” from the “Job” menu of the main 24-Laser window.

The “Test Job” button moves the robot on a test run along the defined trajectory without the use of the laser power. This allows the used it the setting of the via’s and the paths is the expected one. After the test job has been completed successfully, the “Process Job” button can be used to perform the actual welding of the seam.

**Before testing or running a job, ALWAYS ask for the permission of the teacher.**

![Process Job dialog image](image)
A) SurfNet Breeze

CyberLab UTwente Group:  
https://www.surfgroepen.nl/sites/CyberLab/default.aspx

SurfNet Signup:  
https://www.surfgroepen.nl/signup/default.aspx

SurfNet:  
http://www.surfnet.nl/info/home.jsp

B) Cameras and Video Server

Sony Camera  http://130.89.66.191/index.html
Vivotek Camera  http://130.89.66.205:81/
Axis Video Server  http://130.89.66.205/view/index.shtml

C) CyberLab links

Main Site:  
http://www.extra.ivf.se/cyberlab/

Partners:

Twente
Lulea
Budapest
Paris
## Laser Power Calculation Table

This table contains the power th

<table>
<thead>
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<th>Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 mm</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td></td>
</tr>
<tr>
<td>Zinc Coated Steel</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td></td>
</tr>
</tbody>
</table>