Load cell torques and force data collection during tele-operated robotic gas tungsten arc welding in presence of collisions

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\section*{Abstract}
Torque and force signals data were acquired from a load-cell sensor during a robotic welding process, in presence of collisions between the tool and the workpiece edges outlined in part in “Haptic-based touch detection for collaborative robots in welding applications” [1]. The dataset is composed from 15 tests captured during a tele-operated welding robot performing a 1G ASME/AWS (i.e., PA ISO) welding process. The raw data files have been provided. These data can be used to correlate torque signal features with collision events, to improve algorithms of collision detection/avoidance and to develop reliable real-time haptic feedback to the welder. This dataset can also be used to study the torque signal variation in different welding positions (e.g., 2G, 3G, 2F, etc.). Dataset is provided as raw data and in MATLAB files.

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Specifications table

| Subject                                    | Industrial and Manufacturing Engineering |
|--------------------------------------------|------------------------------------------|
| Specific subject area                      | Human-Robot Interaction, welding process, computer science and Industry 4.0. |
| Type of data                               | Tables and MATLAB files                  |
| How data were acquired                     | Data acquired through the load cell, an ATI Mini45-E, communicating through a Local Area Network (LAN) with a 1000BASE-T Gigabit Ethernet wiring. The load cell was mounted on the end-effector of a tele-operated welding robot. |
| Data format                                | Raw                                      |
| Parameters for data collection             | Torques, force and collisions data were collected during a Gas Tungsten Arc Welding (GTAW) performed by a skilled operator with a remotely controlled 6-axis robotic arm (Mitsubishi MELFA RV-13FM-D with a CR750-D controller). The end-effector mounted on the robot wrist includes a process camera (Xiris XVC-1000), a load cell and a GTAW torch assembled with the tip oriented at 90° with respect to z-axis of the robot cell. |
| Description of data collection            | A multi-pass 1G ASME/AWS (i.e., PA ISO) linear welding was performed by the robot on a steel specimen with a manufactured groove. The robot position was real-time corrected by the operator through a haptic interface (Geomagic Phantom Omni). During the welding, the operator intentionally produced collisions between the welding torch tip and the groove edges. Torque and force data were acquired from the load cell with a 3 Hz sampling frequency. |
| Data source location                       | Institution: Nuovo Pignone Plant          |
|                                            | City/Town/Region: Massa (MS)              |
|                                            | Country: Italy                            |
|                                            | Latitude and longitude (and GPS coordinates) for collected samples/data: 44.0354° N, 10.1393° E |
| Data accessibility                         | Mendeley repository:                     |
|                                            | Name: Load cell torques and force data collection during tele-operated robotic Gas Tungsten Arc Welding in presence of collisions |
|                                            | Link: [http://dx.doi.org/10.17632/8m46wcwkrx.1](http://dx.doi.org/10.17632/8m46wcwkrx.1) |
|                                            | DOI: [10.17632/8m46wcwkrx.1](10.17632/8m46wcwkrx.1) |
| Related research article                   | Author: M. Tannous, M. Miraglia, F. Inglese, L. Giorgini, F. Ricciardi, R. Pelliccia, M. Milazzo, C. Stefanini |
|                                            | Title: Haptic-based touch detection for collaborative robots in welding applications |
|                                            | Journal: Robotics and Computer-Integrated Manufacturing |
|                                            | DOI: [https://doi.org/10.1016/j.rcim.2020.101952](https://doi.org/10.1016/j.rcim.2020.101952) |

Value of the data

- These data allow the development of collision detection/avoidance algorithms analyzing torque and force data of a load cell, or, alternatively, they could be used as a training dataset for Neural Networks.
- These data will help researchers who are interested in human-robot interaction, welding robots and real-time collision feedback.
- This dataset can be expanded with other end-effector configurations and/or other kinds of welding positions (e.g., ASME/AWS 2G, 3G, 2F, etc.) to create more general algorithms or evaluate differences and create model-based controls.
- According to the current authors’ knowledge, there are no examples in literature of load cell data in a robotic welding scenario during collisions.

1. Data description

In this article, we present a load cell dataset of torques and force during a tele-operated robotic Gas Tungsten Arc Welding in presence of collisions. The dataset comprises raw data of 15 tests with four columns sorted as in Table 1.

Torques are numerical values expressed in [Nm] while force values are expressed in [N]. Collisions column, instead, are zeros/ones values indicating whether a collision is verified (i.e., ones values) or not (i.e., zeros values). In addition, tests data are provided in .mat files for eventual
processing in MATLAB software. Tests were of few minutes welding a manufacturing groove with weaving movements giving by the operator in 1G ASME/AWS position.

2. Experimental design, materials, and methods

The two main parts that form the architecture of the robotic system (called Remote Welding) are a slave side and a master side.

The master side is the user interface for the system control with the following hardware:

• A controlling workstation with an Intel QuadCore Xeon-E5620 CPU at 2.4 GHz, 250 GB SSD Drive and 12 GB of RAM;
• A customized keyboard to manage process parameters (such as welding current, robot speed, etc.)
• Geomatic Phantom Omni, a haptic interface that is used to send motion commands to the robot and to send force-feedback to the user in case of collisions;
• A monitoring workstation with an Intel QuadCore Xeon E3–1271 CPU at 3.6 GHz, 250 GB SSD DRIVE 250, 8GB of RAM and NVidia Quadro GTX750TI GPU with 2GB, carrying a visual interface to monitor the process and to check the system workflow.

The slave side is used to perform the welding process, and it is composed of the following hardware:

• A 6-DOF robotic arm Mitsubishi MELFA RV-13FM-D with a CR750-D robot controller;
• An end-effector (or tool) installed downstream of the robot sixth axis with a semiautomatic GTAW torch;
• A Xiris XVC-1000 welding camera, with automatic welding detection and filtering for in-process monitoring, connected to the monitoring workstation to provide a clear view of the weld pool;
• An ATI Mini45-E load cell installed between the tool and the wrist, capable of measuring forces and torques.

A schematic structure of the tool and the load cell is shown in Fig. 1. The whole robotic system that form the slave side is installed inside a shielded robotic cell, to protect operators from high temperature, welding smokes and electromagnetic fields.

All the devices are connected through a Local Area Network to send and receive data in a fast and reliable way via Ethernet wiring. A software has been developed as C++ thread to collect torque and force data. The communication with the load cell driver is performed via socket with UDP protocol. Hence, data are stored every 300 ms in a Windows operating system.

The experiment procedure is the following:

• Using the Remote Welding system, the operator moves the robot from the Home position to the working area, placing the tungsten tip on the starting point of the bevel;
• The operator starts welding remotely setting the electrical parameters with the custom keyboard;
• The operator controls the weaving trajectory (i.e., He/she corrects the robot path along the x-axis of the torch), making sure to touch properly the bevel edge with the ceramic cap of the torch, and invert trajectory at the right moment, avoiding further collisions;
• The operator supervises the process through the monitoring workstation screen and provides collision counting;

| Table 1 |
|---------------------|---------------------|---------------------|---------------------|
| **First column**    | **Second column**   | **Third column**    | **Fourth column**   |
| Torque on x-axis    | Torque on y-axis    | Force on x-axis     | Collisions          |


• After a short session of two minutes welding (with an average of 1361 samples acquired from the load cell per session), the procedure is repeated.

Declaration of Competing Interest

The authors financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in declare that they have no known competing this article.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi: 10.1016/j.dib.2020.105981.

Reference

[1] M. Tannous, M. Miraglia, F. Inglese, L. Giorgini, F. Ricciardi, R. Pelliccia, M. Milazzo, C. Stefanini, Haptic-based touch detection for collaborative robots in welding applications, Robotics and Computer-Integrated Manufacturing 64 (2020) 101952.