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DATA PROCESSING IN ORIGIN – ANALYSIS OF TEXTILE FABRIC AND STITCHES STRENGTH

Predrag Pecev[1,2] Anita Milosavljević[3]

[1]University of Novi Sad, iDEAlab, Dr Ilije Đuričića 3, 21000 Novi Sad, Serbia, predrag.pecev@uns.ac.rs, predrag.pecev@gmail.com
[2]Preschool Teacher Training and Business Informatics College of Applied Studies "Sirmium", Zmaj Jovina 29, 22000 Sremska Mitrovica, Serbia
[3]University of Novi Sad, Technical faculty "Mihajlo Pupin", Đure Đakovića bb, 23000 Zrenjanin, Serbia, anita.milosavljevic@hotmail.com

ABSTRACT

This paper describes how we automated data processing for over 2000 fabric samples that were ripped using MESDAN-LAB tensile Strength Tester in order to determine their respective yielding points. Yield point is defined as a point where a sample start to tear and is presented as an ordered pair of two values. First value represents force that was applied to a sample in order for it to start tearing, while the second tracked value represents elongation in which sample started to tear under the previously mentioned applied force. Several tools and development environments where used in order to automate required data processing that consists of three major parts: preprocessing, processing and postprocessing. One C# console application was written for pre and post data processing, and one Python script was written in order to send preprocessed data to Origin 2021 software for batch processing. Processed data can be further analyzed by hand or trough some data analysis and correlation software such as RapidMiner. This paper does not present results and conclusions of the conducted textile samples analysis and focuses solely on the created data processing workflow. Presented workflow can be used as a template for various similar research in textile sciences.

Keywords: Origin, data processing, tensile strength testing, Python, C#.

INTRODUCTION

Origin Processor with pre and post processing was developed out of several reasons. Primary reason was to automatize processing of data that was gathered during a conducted research and to create an automation pattern that we will use in the further research. Created automation pattern is designed to be flexible enough so it can be used in any research regarding tensile strength testing, elongation testing etc. Also, developed automation pattern can be modified and expanded on. Main data processing is done using Origin 2021 software with custom defined analysis template, while developed tools provide processes that are needed in preprocessing and postprocessing phase.

Developed automation pattern is used as a tool in a research whose goal is to analyze textile fabric and stitches strength. Over 2000 textile fabric samples where torn using MESDAN-LAB tensile Strength Tester in order to determine their respective yielding points. Yield point is defined as a point where a sample start to tear and is presented as an ordered pair of two values. First value represents force that was applied to a sample in order for it to start tearing, while the second tracked value represents elongation in which sample started to tear under the previously mentioned applied force. For each torn sample a textual files in CSV (Comma Separated Values) files was generated, and those files are imported into developed Origin Preprocessor. In this paper we will not provide details regarding the goals and results of a research that developed preprocessor was created for, but in later sections of this paper we will provide basic information on the structure of data output that MESDAN-LAB tensile Strength Tester provides as well as our workflow process depicting how we process data in a search for a yield point of a particular sample.

Based on the structure of data that we had to process we have selected set of technologies and software that we used for creating aforementioned automation pattern. Having in mind that all of the gathered data is stored within textual files in CSV (Comma Separated Values) files, and that working with Excel spreadsheets is mandatory, we have chosen to develop Origin Pre and Post processor in a form of a console (command line) application written in C# programming language using Microsoft Visual Studio 2019. Due to previous good experiences with EPPlus Spreadsheet library, the very same was chosen to handle *.csv and *.xlsx files processing.

In order to programmatically automate batch processing in Origin 2021 we have chosen Python3 programming language since support for Python3 was added to Origin software in version of 2021. and its API (Application Programming Interface) can be obtained via PIP. As previously mentioned main data processing is done via Origin 2021. Origin 2021 software is a proprietary computer program for interactive scientific graphing and data analysis. It is produced by OriginLab Corporation, and runs on Microsoft Windows. It has inspired several platform-independent open-source clones and alternatives like LabPlot and SciDAVis. It is often compared to IBM's SPSS.

RELATED WORK

OriginLab Origin software is used in various projects for data processing and data visualization. We have found several papers from various scientific fields that state that Origin software has been used to process and/or visualize presented data. However, based on our experience, it seems that papers such as ours, depicting automatization of data processing using Origin software in combination with other tools, are quite scarce. This can be due to the usage of some other data processing and data visualization software or due to the nature of scientific field to whom the research belongs to. Works of (Rogale, Ujević, Rogale, & Hrastinski, 2011; Barbulov - Popov, Petrović, Ćirković, & Savić, 2011; Barbulov - Popov, Petrović, Reljić, & Savić, 2009; Barbulov - Popov, Petrović, Stepanović, & Savić, 2010; Barbulov - Popov, Petrović, Reljić, & Šehović, 2009; Barbulov - Popov, Petrović, Stepanović, & Reljić, 2009; Petrović, Stojiljković, Božović, & Barbulov - Popov, 2005; Midha & Mukhopadhyay, 2009; Gurarda & Meric, 2005; Barbulov - Popov, Ćirković, Stepanović, & Reljić, 2012; Barbulov - Popov, Ćirković, & Stepanović, 2012) depict usage of Origin software in analysis of various aspects textile fabric and seam strength and describe parts of workflow that we use in our analysis template. However, mentioned papers do not present any higher level of automatization besides batch processing option that Origin software provides. Some of previously mentioned papers do not use batch processing or they have not stated it clearly. In some cases they use some other software in their analysis but maintain workflow very similar to ours.

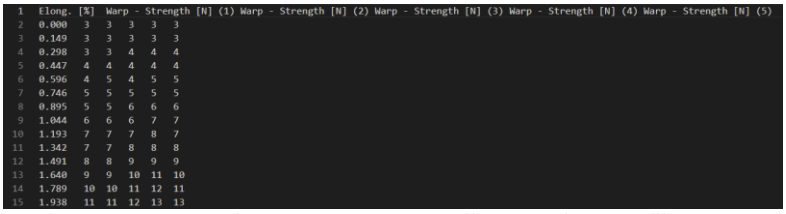
RAW DATA AND FIRST PHASE PROCESSING

Data for each tearing sample consists of 5 tensile strength measurement records over one type of sample. Simply put, a textile fabric sample with specific features is replicated 5 times, and each replicated sample is stretched and torn using MESDAN-LAB tensile Strength Tester. Figure 1 shows aforementioned device.

Figure 1. MESDAN-LAB tensile Strength Tester (TENSO-LAB).

Data for each measurement record is an array of integer values that shows how applied force changes while sample textile fabric is being stretched and inevitably torn. While sample is being stretched elongation of that sample is also being recorded. Elongation is a floating point value. Based on those records we create one average approximated textile fabric tearing data that represents that sample. We are interested in elongation and applied force values up to the tearing point (highest applied force). Values behind that point are ignored.

Figure 2 shows contents of a textual file with CSV structure that contains measurement records for one sample that is formed and outputted by MESDAN-LAB tensile Strength Tester. First column contains elongation values and it is followed by five columns each containing applied force values for each replicated torn sample. Files containing aforementioned data are stored within specially named directories that consists of indicators that point out values of specific features of torn textile fabric sample.



Elong. [%]	Warp - Strength [N] (1)	Warp - Strength [N] (2)	Warp - Strength [N] (3)	Warp - Strength [N] (4)	Warp - Strength [N] (5)
0.000	3	3	3	3	3
0.149	3	3	3	3	3
0.298	3	3	4	4	4
0.447	4	4	4	4	4
0.596	4	5	4	5	5
0.746	5	5	5	5	5
0.895	5	5	6	6	6
1.044	6	6	6	7	7
1.193	7	7	7	8	7
1.342	7	7	8	8	8
1.491	8	8	9	9	9
1.640	9	9	10	11	10
1.789	10	10	11	12	11
1.938	11	11	12	13	13

Figure 2. Contents of a MESDAN-LAB tensile Strength Tester file output.

Goal of the first phase is to create templated Microsoft Excel (*.xlsx) files for each aforementioned textual file. Microsoft Excel files are created by invoking developed Origin Preprocessor via created batch file shown in figure 3.

```
@echo off
TITLE Origin Preprocessor - Generate Excel Files
echo ..:: Generate Excel Files ::...
:: --gef - Generate Excel Files - 2 arguments
:: argument 1 : Path to directory with data
:: argument 2 : find peaks - true / false
origin-preprocesor.exe --gef "E:\\for_analysis\\DATA" "true"
echo ..:: Completed ::..
pause
```

Figure 3. Origin Preprocessor – Generate Excel Files – Batch file.

From figure 3 it can be seen that Origin Preprocessor is invoked by passing parameter "--gef" meaning Generate Excel Files with parameters denoting path to directory that contains previously mentioned textual files and a boolean value that indicates if Origin Preprocessor should find peaks of average approximate textile fabric tearing data automatically using developed algorithm, or should it be left for the user to do it manually.

Created Microsoft Excel file has two tabs. Second tab, shown in figure 4, contains neatly formatted data from a textual file and average approximate textile fabric tearing data that is calculated out of previously mentioned data. We form one average approximated textile fabric tearing data since we want to display general properties of a tested textile fabric sample from 5 tensile strength measurement records. First tab, shown in figure 5, contains summary data that shows maximum applied force of an average approximated textile fabric tearing data out of five replicated samples, and measured values for elongation and applied force that are closest to aforementioned maximum applied force. In rare cases difference between maximum applied force and closest measured applied force differ in values above 3N (Newtons) and it is common for those values to either differ in values between 1 and 3N (which is negligible) or not to differ at all. Summary tab also contains placeholders denoted via label Processed for yield point values that will be obtained trough batch data processing in Origin 2021 and updated in postprocessing phase. Simply put, yield point denoted with Processed tag represents a point where textile fabric sample

starts to tear, and yield point denoted with Measured tag represents a point where textile fabric sample is torn.

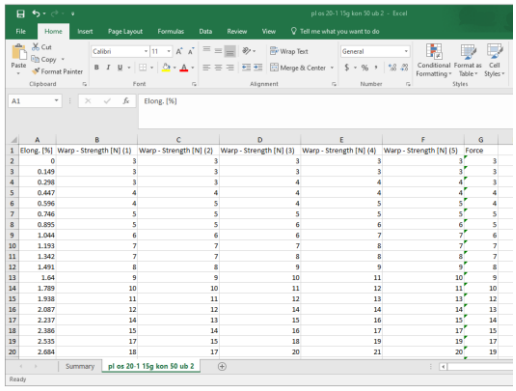


Figure 4. Data of a generated Excel file.

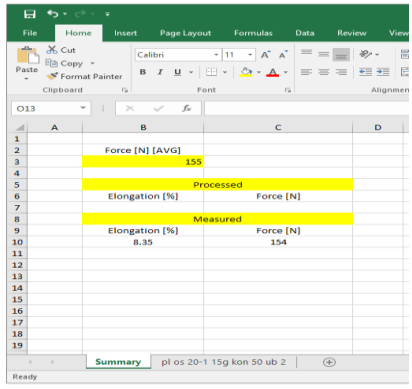


Figure 5. Summary of a generated Excel file.

SECOND PHASE PREPROCESSING

In second phase of preprocessing, based on generated Microsoft Excel files from first phase of preprocessing, we generate CSV files that contain data representing average approximate textile fabric tearing data that is to be batch processed using Origin 2021 software. We create aforementioned CSV files by invoking developed Origin Preprocessor via created batch file shown in figure 6.

```
@echo off
TITLE Origin Preprocessor - Generate CSV Files
echo ..:: Generate CSV Files ::...
:: --gcf - Generate CSV Files - 2 arguments
:: argument 1 : Path to directory with data
:: argument 2 : find peaks - true / false
origin-preprocesor.exe --gcf "E:\\for_analysis\\DATA" "true"
echo ..:: Completed ::..
pause
```

Figure 6. Origin Preprocessor – Generate CSV Files – Batch file.

From figure 6 it can be seen that Origin Preprocessor is invoked by passing parameter "--gcf" meaning Generate CSV Files with parameters denoting path to directory that contains previously mentioned Microsoft Excel files and a boolean value that indicates if Origin Preprocessor should find peaks of average approximate textile fabric tearing data automatically using developed algorithm, or should it be left for the user to do it manually.

WHAT HAVE WE AUTOMATED?

Data from generated CSV file can be imported to Origin 2021 software manually by selecting Batch Processing dialog from File menu and selecting proper analysis template file as shown in figure 7.

Based on the imported data from CSV file, analysis template we defined creates a Scatter plot and then performs a Polynomial fit of highest available order which is this case 9th order. Out of generated Polynomial fit curve, we calculate 1st and 2nd derivative and then we seek for a maximum value (Peak Analyzer - Peak Centers) of a 1st derivative which represents a yield point value depicting elongation.

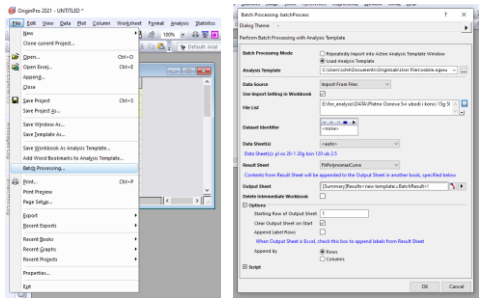


Figure 7. Accessing Batch Processing dialog selecting Analysis template and feeding it CSV data.

Based on calculated elongation value, we look for paired applied force value, and that is how we form a yield point for analyzed sample. Figure 8 shows content of a processed CSV file, while figure 9 shows results of a processed CSV file in Origin 2021 software.

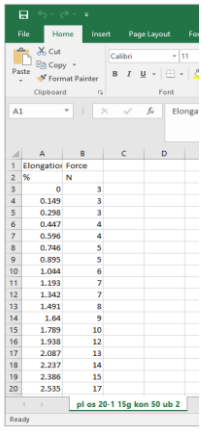


Figure 8. CSV file.

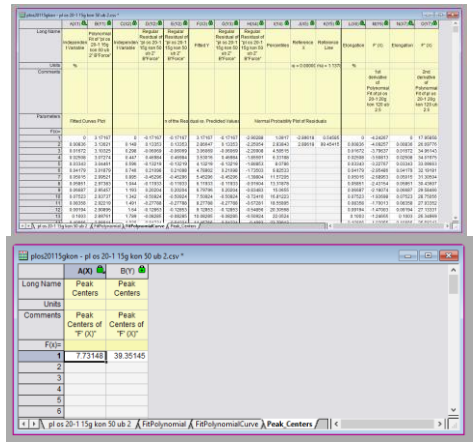


Figure 9. Results of Origin 2021 processing.

DATA PROCESSING IN ORIGIN – PYTHON SCRIPT

As shown in previous chapter of this paper, Origin 2021 software incorporates a feature that allows us to do batch processing. However, due to the quantity and file and folder structure of gathered data and some of the custom conditions we needed to apply regarding processing of previously mentioned data, we decided to use Python3 and Origin API that can be obtained via PIP to fully automate required data processing. Figure shows developed Python 3 script running in a PowerShell terminal within Microsoft Visual Studio Code IDE.

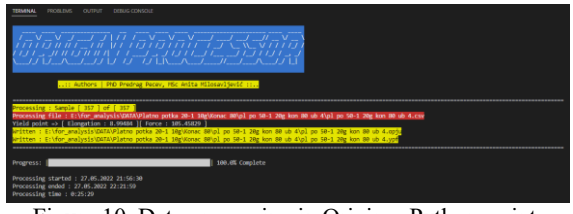


Figure 10. Data processing in Origin – Python script.

From figure 10 it can be seen that 357 data samples have been processed on 27th of May 2022, and aforementioned processing took around 25 minutes. During data processing name of CSV data file is displayed and calculated yield point is displayed. Once yield point is calculated, *.opju (Origin project file) containing all of the processed data is saved, and small *.ypf (Yield

Point File) containing calculated yield point in JSON format is created and saved. After data has been processed in Origin 2021 software using developed Python3 script, in each directory that contains initial textual file that was processed in the First phase of preprocessing, four additional files can be found as shown in figure 11.

Figure 11. Files used in data processing.

From figure 11 we can see that all of the files have the same file name, and different file extension. Files are named automatically based on the name of the folder they are stored in. As previously mentioned directories have specific names that consists of indicators that point out values of specific features of a torn textile fabric sample. Based of the name of file extension, purpose of all the files shown in figure 11 are:

- *.txt - MESDAN-LAB tensile Strength Tester output file that contains raw data of a sample that is to be processed.
- *.xslx – File that contains neatly formatted data from *.txt file and average approximated textile fabric tearing data that represents that sample.
- *.csv – File that contains average approximated textile fabric tearing data in appropriate format so it can be imported into Origin 2021 and processed properly.
- *.opju - Origin project file containing all of the data that was processed in Origin 2021 software regarding one processed data sample.
- *.ypf – Yield Point file containing calculated yield point of processed data sample in JSON format.

FIRST PHASE POSTPROCESSING

Once main processing is done, in the first phase of postprocessing we update Microsoft Excel files that we generated in the first phase of preprocessing with data from yield point files. This is done by invoking developed Origin Postprocessor via created batch file shown in figure 12.

```
1  @echo off
2  TITLE Origin Postprocessor - Update Excel Files
3  echo ..:: Update Excel Files ::...
4  :: --uef - Update Excel Files - 1 argument
5  :: argument 1 : Path to directory with data
6  origin-preprocesor.exe --uef "E:\\for_analysis\\DATA"
7  echo ..:: Compleeted ::..
8  pause
```

Figure 12. Origin Postprocessor – Update Excel Files – Batch file.

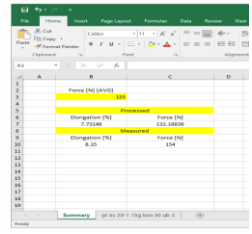


Figure 13. Updated Microsoft Excel file.

From figure 12 it can be seen that Origin Postprocessor is invoked by passing parameter "--uef" meaning Update Excel Files with parameters denoting path to directory that contains both previously mentioned Microsoft Excel files and yield point files. Figure 13 shows Microsoft Excel file with updated processed yield point values.

SECOND PHASE POSTPROCESSING

In second phase of postprocessing we create one large Microsoft Excel file that summarizes all of the data from first sheet of generated Microsoft Excel files that contain data of all of the raw and processed data samples. We create aforementioned Microsoft Excel files by invoking developed Origin Postprocessor via created batch file shown in figure 14.

```
@echo off
TITLE Origin Postprocessor - Update Summary File
echo ..:: Update Summary File ::...
:: --usf - Update Summary File - 2 arguments
:: argument 1 : Path to directory with data
:: argument 2 : Path to xls file that will store data
origin-preprocesor.exe --usf "E:\\for_analysis\\DATA" "E:\\for_analysis\\OUTPUT\\generated_data.xlsx"
echo ..:: Compleeted ::..
pause
```

Figure 14. Origin Postprocessor – Update Summary File – Batch file.

From figure 14 it can be seen that Origin Postprocessor is invoked by passing parameter "--usf" meaning Update Summary Files with parameters denoting path to directory that contains Microsoft Excel files that are to be summarized, and a path to a Microsoft Excel file where data from the aforementioned files is to be summarized and stored. Results of second phase postprocessing can be seen in figure 15.

								Processed		Measured			
Sample ID	Sample Name	Direction	FWF	ED	FT	Stitch	EL [%]	Force[N]	EL [%]	Force [N]	Δ EL [%]	Δ Force [N]
Sample 0001	pl os 20-1 10g kon 100 ub 2	Warp	20-1	10g	100	2	7.42023	110.05637	8.867	150	1.44677	39.94363
Sample 0002	pl os 20-1 10g kon 100 ub 2.5	Warp	20-1	10g	100	2.5	6.93297	91.03871	8.745	138	1.81203	46.96129
Sample 0003	pl os 20-1 10g kon 100 ub 3	Warp	20-1	10g	100	3	7.84058	179.26088	9.682	258	1.84142	78.73912
Sample 0004	pl os 20-1 10g kon 100 ub 3.5	Warp	20-1	10g	100	3.5	8.906	164.76168	8.906	164	0	0.76168
Sample 0005	pl os 20-1 10g kon 100 ub 4	Warp	20-1	10g	100	4	7.15698	84.72931	9.19	129	2.03302	44.27069
Sample 0006	pl os 20-1 15g kon 100 ub 2	Warp	20-1	15g	100	2	4.00803	40.27837	8.648	109	4.63997	68.72163
Sample 0007	pl os 20-1 15g kon 100 ub 2.5	Warp	20-1	15g	100	2.5	8.47119	120.87781	8.797	127	0.32581	6.12219
Sample 0008	pl os 20-1 15g kon 100 ub 3	Warp	20-1	15g	100	3	8.74646	100.59829	9.217	110	0.47054	9.40171
Sample 0009	pl os 20-1 15g kon 100 ub 3.5	Warp	20-1	15g	100	3.5	8.56381	91.69774	9.082	103	0.51819	11.30226
Sample 0010	pl os 20-1 15g kon 100 ub 4	Warp	20-1	15g	100	4	8.28925	101.47203	8.635	109	0.34575	7.52797
Sample 0011	pl os 20-1 20g kon 100 ub 2	Warp	20-1	20g	100	2	7.11015	84.80085	9.408	123	2.29785	38.19915
Sample 0012	pl os 20-1 20g kon 100 ub 2.5	Warp	20-1	20g	100	2.5	6.51711	72.37932	8.81	111	2.29289	38.62068
Sample 0013	pl os 20-1 20g kon 100 ub 3	Warp	20-1	20g	100	3	6.26362	72.05667	9.095	109	2.83138	36.94333
Sample 0014	pl os 20-1 20g kon 100 ub 3.5	Warp	20-1	20g	100	3.5	6.2515	75.25274	8.25	108	1.9985	32.74726

Figure 15. Summary file that contains results of all of processed textile fabric samples.

As shown in figure 15 for each sample both Processed (textile fabric sample starts to tear) and Measured (textile fabric sample is torn) values of yield points are stored. Elongation is denoted EL [%] while applied force is denoted as Force [N]. Differences in elongation and applied force (denoted with Δ EL [%] and Δ Force [N]) between Processed and Measured yield points are also calculated and stored.

Legend of tracked parameters of textile fabric samples that where processed is as follows:

- Direction: Warp of Weft
- FWF – The fineness of the weft fabric
- ED - Existing density
- FT - The finesse of the thread
- Stitch (Seam) – Puncture width

CONCLUSIONS

Created tools provide functionality that we aimed for and can be used in a variety of projects that include tensile strength testing, elongation testing, tear testing etc. in various "material" industries, such as textile, cardboard, leather and many others.

Once we wrote both pre and post processor, we found out that there is excellent Python library for XLSX and CSV file creation and editing called XlsxWriter, so regarding further development our goal is to rewrite both pre and post processor using Python3 programming language and aforementioned library so we can make our automation pattern more user friendly for altering models and/or scripts in presented workflow. Compared to C#, it is well known that Python is easier to learn, read and write do to its syntax. Also, it is easier to set up a Python development / modding environment than to get familiarized with Microsoft Visual Studio and C# programming language. Once pre and post processor are rewritten they will be available on GitHub as an Open-Source project and then, based on users feedback, we will see how to further expand on and upgrade current workflow model and created automation pattern.

As a next goal in expanding the presented workflow we will incorporate support for integration with specialized data analysis and correlation software such as RapidMiner, Alteryx

etc. Having in mind in the final phase of the current workflow we store results from all of the processed data samples in one Microsoft Excel file, various analysis can be done within Microsoft Excel itself using CORREL function or Data Analysis Toolpak. However, but we think that previously mentioned approach will yield far more interesting results.

LITERATURE

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