

**REPORT**

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**PROJECT TITLE: WRITING AND TESTING AN ALGORITHM TO CONVERT DIGITAL IMAGES TO PHYSICAL 2D IMAGES**

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# introduction:

The main source of inspiration for this project came from watching YouTube videos. These videos included topics such as the writing of algorithms, specific the video by (Buekban, 2014); DIY 3D printers, Arduino projects, specific video by (GUY, 2018), and other similar topics. Some of these videos included clips of self-made / DIY printers, which could be improved upon. Thus, the idea was formed of conducting research, writing an algorithm to convert digital images into physical images and building a DIY printer.

# Background research including literature review

Some of the earliest inspiration for writing an algorithm to convert digital images in physical images, came from path finding algorithms such as A\*, which finds the shortest distance between all the points. This will allow the image to be printed in the smallest amount of time possible. However, due to limitations on the DIY printer, this algorithm was abandoned in favour of a more linear pattern which prints all the pixels (dots) in a single row, before moving on to the next row, and so on.

Many of the later ideas came from the flood searching algorithm. This algorithm provided the bases on which the digital images where scanned to detect dots. The algorithm starts at a point and checks all the spaces around it for a potential dot and also has path finding applications. The distance algorithm’s inspiration came from the popular travelling salesman problem where the goal is to create an algorithm that finds the shortest path between all the dots.

The review of videos online provided a lot of insight and information on how to build the physical printer, specifically the video (RCLifeOn, 2017). This video shows how DIY printer kits are assembles and thereafter reviewed. This was a great bonus since it provided insight into what an end user would expect from a DIY printer.

A recently self-built project using COM ports in C# provided information on how to open and connect to a device using serial communication. This made it much easier to create an application that utilizes Bluetooth to wirelessly transmit the instructions to the DIY printer.

The main challenge in writing this algorithm, was to create an algorithm that detects and sorts all the points the printer will have to print.

The results from the data analysis (survey) indicated the following as being a high priority for users:

|  |  |  |
| --- | --- | --- |
|  | | Priority % |
| 1 | Quality | 87 |
| 2 | Quantity | 80 |
| 3 | Printing Abstract Image | 79 |

# Problem

The problem that is aimed to be solved, is to determine whether it is possible to successfully write an algorithm to convert digital images that the user draws in the created software, into send able instructions that will be transmitted to a DIY printer.

# Aim

The aim of this project is to increase awareness and understanding of how an algorithm can be written and applied to a DIY printer application that can effectively, reliably scan and reproduce images.

# Hypothesis

Is it possible to write an algorithm that can convert a digital image on the user’s computer into instructions that can be transmitted (sent) to a home-made printer in order for it to convert the virtual image into an actual 2D image on a page?

# Variables and Method

The application was written in C# and utilizes a pre-existing library to control and communicate with the stepper motors in the DIY printer.

The main method creating the software was based on trial and error. All the algorithms that were used during this project had one thing in common. They all started by scanning for a printable dot in a linear fashion. The linear algorithm then took these dots and printed them in the exact order as they were initially scanned by the computer with the exception of going from left to right, every second row instead of right to left. This was done to decrease the overall printing time.

Some of the algorithms that were tested included linear algorithms that scanned all the dots with the same X – Coordinate before moving down to the next row. Another algorithm that was tested, used the distance algorithm which checks the distance between all the scanned dots to see which dot is the closest to the other. This algorithm is inspired by the “traveling salesperson problem” where the goal is to write an algorithm to find the shortest possible path between all the “Cities” or in this case dots.

The first step was to create a GUI that the user interacts with and that contains the following aspects:

* Page orientation.
* Printer information.
* Printer status.
* COM Port the printer is connected to.
* Pen position on page.
* Scan button.
* Connect button.
* Start button.
* Settings and file preferences.

The next step was to add the functionality that allows the user to draw an image in the created software. This is done by checking whether the mouse button is down and where on the page the cursor is. It then uses these coordinates to draw a black pixel on an image. This image is then displayed on the GUI and represents the picture for the printer to print. The program also includes a functionality to allow the user to import pre-made images into the application at this stage.

When the user presses the scan button the software checks each pixel of the image and then add all the black pixels (coloured pixels) it finds to an array. Next the software checks the current location of the pen (printing head) with respect to the pixel it will draw and moves the printing head accordingly to the correct position along with raising and lowering the pen as needed. Then it moves on until all the pixels have been drawn before the printing head returns to the (0; 0) coordinate.

# Results

## Results of survey (questionnaire)

### Steps taken to develop a questionnaire .

#### Decide what I wanted to learn – the goal of my questionnaire:

* Would different sexes prefer different outputs;
* Would different ages prefer different outputs;
* Would the quality of the image be a consideration;
* Would quantity of images being printed be a consideration;
* Would printing time be a consideration;
* Would users prefer an abstract or realistic printed image;
* Would users use the application to draw their own images or would they prefer to import images to be printed, from an external source;
* Would users be interested in building their own DIY printer to utilize this application?

#### Decide who my target population would be - what type of people I want to interview:

* Fellow Information Technology students in Hartbeespoort High;
* Information Technology students in other High schools in the region;
* Friends;
* Information Technology Teachers and family members.

#### Decide on a sample size (the larger the sample the more accurate the results):

* ± 20 Fellow Information Technology students in Hartbeespoort High;
* ± 60 Information Technology students in other High schools in the region;
* ± 10 friends;
* ± 10 Information Technology Teachers and family members.

#### Decide on a method of data collection:

* Ask people to complete a written questionnaire;
* Interview people and complete the questionnaire based on their responses;
* E-mail a questionnaire to people.

#### Decide on how respondents need to answer the questions:

* Should it be open ended questions with written answers from the respondents;
* Should the respondent’s answers be based on a rating for example “Agree”, “Disagree” etc. (Thus a tick box can be used).

### Example of survey developed (Refer to the Journal file for an example of the survey questionnaire used)

### Conducting the survey

A survey was conducted using the above-mentioned questionnaire. The sample consisted of the following respondents:

* + 20 Fellow Information Technology students in Hartbeespoort High;
  + 60 Information Technology students in other High schools in the region;
  + 10 friends;
  + 10 Information Technology Teachers and family members.

The feedback received from the respondents was captured in an Excel spreadsheet (refer to data analyses spreadsheets within the Journal file.) Basic statistical techniques for example averages per group were used for the data analysis.

#### Gender of respondents

Table 1:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Male** | **Female** | **Total** |
| **Gender of respondents** | 57 | 43 | 100 |

Graph 1:

#### Age of Respondents

The age of the respondents was also considered and resulted in the following:

Table 2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **17 to 20** | **21 to 30** | **30+** | **Total** |
| **Age or respondents** | 90 | 4 | 6 | 100 |

Graph 2:

#### Results from female respondents

The results obtained from the female respondents showed the following results:

Table 3:

|  |  |  |  |
| --- | --- | --- | --- |
| **Question No** | **Question** | **Number of Respondents** | **Average (%)** |
| 1 | Is the quality of the image important? | 43 | 88 |
| 2 | Is quantity of images important? | 43 | 67 |
| 3 | Do you prefer a more abstract image over a realistic image? | 43 | 83 |
| 4 | Is the speed of printing important? (The quicker the printing the poorer the quality) | 43 | 57 |
| 5 | Would you use the application to draw your own images? | 43 | 75 |
| 6 | Would you use the application to import images from external sources? | 43 | 66 |
| 7 | Would you utilize a function for saving your work? (Picture drawn) | 43 | 65 |
| 8 | Would you prefer to be able to see the printing status information? | 43 | 49 |
| 9 | Would you want to choose the page orientation? | 43 | 73 |
| 10 | Would you consider building your own DIY printer for this application? | 43 | 41 |

Graph 3:

#### Results from male respondents

The results from the male correspondents showed a definite difference in preference and yielded the following:

Table 4:

|  |  |  |  |
| --- | --- | --- | --- |
| **Question No** | **Question** | **Number of Respondents** | **Average (%)** |
| 1 | Is the quality of the image important? | 57 | 73 |
| 2 | Is quantity of images important? | 57 | 85 |
| 3 | Do you prefer a more abstract image over a realistic image? | 57 | 88 |
| 4 | Is the speed of printing important? (The quicker the printing the poorer the quality) | 57 | 94 |
| 5 | Would you use the application to draw your own images? | 57 | 50 |
| 6 | Would you use the application to import images from external sources? | 57 | 81 |
| 7 | Would you utilize a function for saving your work? (Picture drawn) | 57 | 78 |
| 8 | Would you prefer to be able to see the printing status information? | 57 | 78 |
| 9 | Would you want to choose the page orientation? | 57 | 80 |
| 10 | Would you consider building your own DIY printer for this application? | 57 | 82 |

Graph 4:

#### Male versus female feedback

When the male and female feedback is compared it showed that there is a definite difference in what each gender considers being important as showed in Table 5 as well as Graph 5.

Table 5:

|  |  |  |  |
| --- | --- | --- | --- |
| **Question No** | **Question** | **Male (%Avg)** | **Female (%Avg)** |
| 1 | Quality | 73 | 88 |
| 2 | Quantity | 85 | 67 |
| 3 | Abstract Image | 88 | 83 |
| 4 | Printing Speed | 94 | 57 |
| 5 | Draw Own Image | 50 | 75 |
| 6 | Import Externally | 81 | 66 |
| 7 | Saving Function | 78 | 65 |
| 8 | Printing Status | 78 | 49 |
| 9 | Page Orientation | 80 | 73 |
| 10 | DIY Printer | 82 | 41 |

Graph 5:

#### Age 17 to 20 feedback

The feedback from the age group 17 to 20 indicated that they have different requirements than the rest of the age groups. Since most of the respondents fell in this age group, they had the biggest influence on the outcome of the survey. Their feedback is summarised in Table 6 below:

Table 6:

|  |  |  |  |
| --- | --- | --- | --- |
| **Question No** | **Question** | **Number of Respondents** | **Average (%)** |
| 1 | Is the quality of the image important? | 90 | 87 |
| 2 | Is quantity of images important? | 90 | 80 |
| 3 | Do you prefer a more abstract image over a realistic image? | 90 | 83 |
| 4 | Is the speed of printing important? (The quicker the printing the poorer the quality) | 90 | 72 |
| 5 | Would you use the application to draw your own images? | 90 | 71 |
| 6 | Would you use the application to import images from external sources? | 90 | 81 |
| 7 | Would you utilize a function for saving your work? (Picture drawn) | 90 | 67 |
| 8 | Would you prefer to be able to see the printing status information? | 90 | 71 |
| 9 | Would you want to choose the page orientation? | 90 | 72 |
| 10 | Would you consider building your own DIY printer for this application? | 90 | 79 |

Graph 6:

#### Feedback from age group 21 to 30

The feedback from this age group showed that their focus is totally different than the age group mentioned before. The results from the age group 21 to 30 is shown below in Table 7 and Graph 7.

Table 7:

|  |  |  |  |
| --- | --- | --- | --- |
| **Question No** | **Question** | **Number of Respondents** | **Average (%)** |
| 1 | Is the quality of the image important? | 4 | 83 |
| 2 | Is quantity of images important? | 4 | 92 |
| 3 | Do you prefer a more abstract image over a realistic image? | 4 | 50 |
| 4 | Is the speed of printing important? (The quicker the printing the poorer the quality) | 4 | 75 |
| 5 | Would you use the application to draw your own images? | 4 | 67 |
| 6 | Would you use the application to import images from external sources? | 4 | 92 |
| 7 | Would you utilize a function for saving your work? (Picture drawn) | 4 | 83 |
| 8 | Would you prefer to be able to see the printing status information? | 4 | 75 |
| 9 | Would you want to choose the page orientation? | 4 | 75 |
| 10 | Would you consider building your own DIY printer for this application? | 4 | 75 |

Graph 7:

#### Feedback from age group 30+

The results obtained from the age group 30+ indicated a more mature approach to their requirements. Focussing on saving functions as well as overall quality.

Table 8:

|  |  |  |  |
| --- | --- | --- | --- |
| **Question No** | **Question** | **Number of Respondents** | **Average (%)** |
| 1 | Is the quality of the image important? | 6 | 94 |
| 2 | Is quantity of images important? | 6 | 72 |
| 3 | Do you prefer a more abstract image over a realistic image? | 6 | 50 |
| 4 | Is the speed of printing important? (The quicker the printing the poorer the quality) | 6 | 89 |
| 5 | Would you use the application to draw your own images? | 6 | 50 |
| 6 | Would you use the application to import images from external sources? | 6 | 89 |
| 7 | Would you utilize a function for saving your work? (Picture drawn) | 6 | 94 |
| 8 | Would you prefer to be able to see the printing status information? | 6 | 50 |
| 9 | Would you want to choose the page orientation? | 6 | 83 |
| 10 | Would you consider building your own DIY printer for this application? | 6 | 50 |

Graph 8:

#### Comparison of the feedback from the different age groups

The comparison of the feedback from the different age groups indicated a clear difference in preference and requirements, as indicated in the table below.

Table 9:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question Number** | **Question** | **17 - 20** | **21 - 30** | **30+** |
| 1 | Quality | 87 | 83 | 94 |
| 2 | Quantity | 80 | 92 | 72 |
| 3 | Abstract Image | 83 | 50 | 50 |
| 4 | Printing Speed | 72 | 75 | 89 |
| 5 | Draw Own Image | 71 | 67 | 50 |
| 6 | Import Externally | 81 | 92 | 89 |
| 7 | Saving Function | 67 | 83 | 94 |
| 8 | Printing Status | 71 | 75 | 50 |
| 9 | Page Orientation | 72 | 75 | 83 |
| 10 | DIY Printer | 79 | 75 | 50 |

Graph 9:

#### Comparison of the results from all the ages combined

The results from all the ages combined is shown in Table 10 below:

Table 10:

|  |  |  |
| --- | --- | --- |
| **Question Number** | **Question** | **%Avg** |
| 1 | Quality | 87 |
| 2 | Quantity | 80 |
| 3 | Abstract Image | 79 |
| 4 | Printing Speed | 73 |
| 5 | Draw Own Image | 70 |
| 6 | Import Externally | 82 |
| 7 | Saving Function | 69 |
| 8 | Printing Status | 70 |
| 9 | Page Orientation | 73 |
| 10 | DIY Printer | 77 |

Graph 10:

## Results of algorithm testing

Five different algorithms were used for testing this hypothesis. The different algorithms consisted of the following:

1. Linear (1000 ms): This was the original algorithm developed for this project but soon became out dated. The linear refers to the fact that the algorithm prints all the dots from left to right on a specific height before moving down and again printing from left to right. 1000 ms indicates the delay between each instruction sent to the printer.
2. Linear (775 ms): This was the improvement on the 1000 ms algorithm since it prints at a faster speed but still maintains a high printing quality.
3. Distance (775 ms): The “distance” referring to the fact that this algorithm considers the distance between two dots and always chooses to travel to the next closest dot relevant to its current position.
4. Distance (dots): Used to improve the printing quality this algorithm raises and lowers the pen after each point it draws to eliminate possible “wobble”.
5. Distance (1000 ms): To improve the printing quality and to possibly find the best overall algorithm the Distance algorithm’s 775 ms was reduced to a speed of 1000ms.

Twenty-two (22) tests were conducted in total (refer to the data analyses section in the Journal file for the raw data).

### The number of tests per algorithm

The number of tests per algorithm is indicated in Table 1 and Graph 1 below.

Table 1:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Linear (1000 ms)** | **Linear  (775 ms)** | **Distance  (775 ms)** | **Distance (Dots)** | **Distance (1000 ms)** |
| **Number of Tests done per type of test** | 3 | 5 | 6 | 6 | 2 |

Graph 1:

### Criteria used to compare the algorithms

The following criteria were used to compare the different algorithms:

1. Quality of printing.
2. Reliability.
3. Accuracy.
4. Repeatability.

### Rating scale

The following rating scale was used, and a number as indicated in brackets was allocated to each to quantify the results:

1. Excellent (5).
2. Very Good (4).
3. Good (3).
4. Weak (2).
5. Poor (1).

### Quality average for different algorithms

The quality obtained for each of algorithms are shown in Table 2 and Graph 2 below.

Table 2:

|  |  |  |
| --- | --- | --- |
|  | **Quality Rating for different Test Algoritms** | **%Avg  Quality** |
| 1 | Algorithm: Linear (1000 ms) | 40 |
| 2 | Algorithm: Linear (775 ms) | 80 |
| 3 | Algorithm: Distance (775 ms) | 37 |
| 4 | Algorithm: Distance (Dots) | 63 |
| 5 | Algorithm: Distance (1000 ms) | 80 |

Graph 2:

### Reliability average for each algorithm

The reliability obtained for each algorithm is shown in Table 3 and Graph 3 below.

Table 3:

|  |  |  |
| --- | --- | --- |
|  | **Quality Rating for different Test Algoritms** | **%Avg  Reliability** |
| 1 | Algorithm: Linear (1000 ms) | 40 |
| 2 | Algorithm: Linear (775 ms) | 64 |
| 3 | Algorithm: Distance (775 ms) | 47 |
| 4 | Algorithm: Distance (Dots) | 43 |
| 5 | Algorithm: Distance (1000 ms) | 60 |

Graph 3:

### Accuracy average for each algorithm

The accuracy obtained for each algorithm is shown in Table 4 and Graph 4 below.

Table 4:

|  |  |  |
| --- | --- | --- |
|  | **Quality Rating for different Test Algoritms** | **%Avg  Accuracy** |
| 1 | Algorithm: Linear (1000 ms) | 47 |
| 2 | Algorithm: Linear (775 ms) | 76 |
| 3 | Algorithm: Distance (775 ms) | 40 |
| 4 | Algorithm: Distance (Dots) | 33 |
| 5 | Algorithm: Distance (1000 ms) | 60 |

Graph 4:

### Repeatability average of each algorithm

The repeatability obtained for each algorithm is shown in Table 5 and Graph 5 below.

Table 5:

|  |  |  |
| --- | --- | --- |
|  | **Quality Rating for different Test Algoritms** | **%Avg  Repeatability** |
| 1 | Algorithm: Linear (1000 ms) | 33 |
| 2 | Algorithm: Linear (775 ms) | 64 |
| 3 | Algorithm: Distance (775 ms) | 50 |
| 4 | Algorithm: Distance (Dots) | 43 |
| 5 | Algorithm: Distance (1000 ms) | 60 |

Graph 5:

### Comparison of all the data

The comparison of all the data obtained for each algorithm is shown in Table 6 and Graph 6 below.

Table 6:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Comparison of all data** | **%Avg  Quality** | **%Avg  Reliability** | **%Avg  Accuracy** | **%Avg  Repeatability** |
| 1 | Algorithm: Linear (1000 ms) | 40 | 40 | 47 | 33 |
| 2 | Algorithm: Linear (775 ms) | 80 | 64 | 76 | 64 |
| 3 | Algorithm: Distance (775 ms) | 37 | 47 | 40 | 50 |
| 4 | Algorithm: Distance (Dots) | 63 | 43 | 33 | 43 |
| 5 | Algorithm: Distance (1000 ms) | 80 | 60 | 60 | 60 |

Graph 6:

### Comparison of algorithms overall

The comparison of all the data obtained for each algorithm is shown in Table 7 and Graph 7 below

Table 7:

|  |  |  |
| --- | --- | --- |
|  | **Comparison Algorithms Overall** | **%Avg Overall** |
| 1 | Algorithm: Linear (1000 ms) | 40 |
| 2 | Algorithm: Linear (775 ms) | 71 |
| 3 | Algorithm: Distance (775 ms) | 43 |
| 4 | Algorithm: Distance (Dots) | 46 |
| 5 | Algorithm: Distance (1000 ms) | 65 |

Graph 7:

# Analysis and discussion of results:

## Analysis of survey results

The feedback received from the survey respondents was captured in an Excel spreadsheet (refer to data analyses spreadsheets within the Journal file.)

### Gender of respondents (Section 6.1.3 - Table 1 and Graph 1):

The analysis of the gender of the respondents indicated that there were more male respondents than female respondents.

### Age of the respondents (Section 6.1.3 - Table 2 and Graph 2):

The analysis of the age of the respondents indicated that almost 90% of the respondents were in the age group 17 to 20 years. This is mainly since I have asked students of my own age, who are also taking Information technology as a subject, to complete the survey.

### Analysis of the results from female respondents (Section 6.1.3 - Table 3 and Graph 3)

The results obtained from the female respondents showed that the following aspects were of high importance to them:

* + Quality
  + Ability to print abstract images
  + To draw their own images
  + To choose the page orientation

The female correspondents indicated the following as the least important aspects:

* + Building DIY printer
  + Printing status and printing speed.

### Analysis of the results from the male respondents (Section 6.1.3 – Table 4 and Graph 4)

The results from the male correspondents showed a definite difference in preference and requirements.

The results from the survey for the male respondents indicated the following as being most important for them:

* + Printing speed;
  + Printing abstract images;
  + Quantity;
  + Building DIY printer.

It also showed that the following is the least important for the male respondents:

* + Drawing their own images;
  + Quality;
  + The saving function.

### Male versus female feedback (Section 6.1.3 – Table 5 and Graph 5)

When the male and female feedback is compared it showed that there is a definite difference in what each gender considers being important. Males prefer printing speed, quantity, printing of abstract images as well as an interest in building a DIY printer. However, females seem to prefer quality, drawing their own images and page orientation.

### Analysis of feedback from age group 17 to 20 (Section 6.1.3 – Table 6 and Graph 6)

When analysing the results obtained from the respondents aged 17 – 20 it is evident that the following aspects are important to them:

* + Being able to import images from an external source
  + Printing abstract images
  + Quality
  + Building a DIY printer

The aspects least important to this age group are:

* + Saving function
  + Printing speed
  + Drawing their own images

### Analysis of feedback from age group 21 to 30 (Section 6.1.3 – Table 7 and Graph 7)

The results from the respondents aged 21 – 30 showed the following aspects as being most important to them:

* + Quantity
  + Being able to import from an external source
  + Saving function

The aspects least important to this age group were:

* + Printing abstract images
  + Drawing their own images
  + Printing speed

### Analysis of feedback from age group 30+ (Section 6.1.3 – Table 8 and Graph 8)

The results obtained from the age group 30+ indicated a more mature approach to their requirements.

The analyses of the feedback from respondents aged 30+ indicated the following aspects as being most important to this age group:

* Saving function
* Quality
* Printing speed
* Importing images from external source

The aspects least important to this age group are:

* Printing abstract images
* Drawing their own images
* Printing status
* Building DIY printer

### Analysis and comparison of the feedback from the different age groups (Section 6.1.3 – Table 9 and Graph 9)

It is evident from Table 9 and Graph 9 that the different age groups have some requirements that overlap, for example:

* + Being able to import images from an external source;
  + Quality; and
  + Page orientation.

However, it is also obvious that the different age groups have totally different outlooks when it comes to the following requirements:

* + Printing abstract images;
  + Knowing the printing status;
  + Building a DIY printer.

The overall impression from the data analysis is that the older generations prefer quality, saving functions, printing speed and importing from an external source. Whilst quality is also important for the younger generations, they seem to focus more on are also seems to be more interested in printing abstract images, printing their own images and building DIY printers.

### Analysing the feedback from all ages combined (Section 6.1.3 – Table 10 and Graph 10)

When one analyses the results from all ages combined it clearly shows the following aspects as being most important:

* + Quality
  + Importing from external source
  + Quantity
  + Being able to print abstract images
  + Building a DIY printer

Over all the aspects being least important are:

* + Drawing own images
  + Saving function
  + Printing status

Analysing the comparison from the different age groups it clearly shows that each age group has their preferences. Thus, for the younger generation importing from external sources and building their own DIY printer were highly preferable whilst the older generations opted for the saving function and quality of images. In conclusion the best option would be to write an algorithm that would be able to satisfy most of these preferences.

## Analysis of results of algorithm testing

As indicated in section 6.2, twenty-two (22) tests were conducted in total (refer to the data analyses section in the Journal file for the raw data).

Whilst the goal is to conduct the same number of tests for each algorithm, some algorithms failed or yielded poor results, which resulted in no further tests being conducted with that specific algorithm.

### Analysis of the average quality of printing for the different algorithm tests (Section 6.2 – Table 2 and Graph 2)

The average printing quality obtained indicated that the following algorithms yielded the best quality:

1. Linear (775 ms)
2. Distance (1000 ms)

With the following algorithm obtaining the weakest printing quality:

1. Distance (775 ms)

### Analysis of the average reliability for the different algorithm tests (Section 6.2 – Table 3 and Graph 3)

The average reliability obtained during the tests, indicated that the following algorithms yielded the best reliability:

1. Linear (775 ms)
2. Distance (1000 ms)

With the following algorithm obtaining the weakest reliability:

1. Linear (1000 ms)

### Analysis of the average accuracy of the different algorithm tests (Section 6.2 – Table 4 and Graph 4)

The average accuracy obtained indicated that the following algorithm yielded the best accuracy:

1. Linear (775 ms)

With the following algorithm obtaining the weakest accuracy:

1. Distance (Dots)

### Analysis of the repeatability for the different algorithms (Section 6.2 – Table 5 and Graph 5)

The average repeatability obtained during the tests, indicated that the following algorithms yielded the best repeatability:

1. Linear (775 ms)
2. Distance (1000 ms)

With the following algorithm obtaining the weakest repeatability:

1. Linear (1000 ms)

### Analysis or comparison of all the algorithms – overall (Section 6.2 – Table 7 and Graph 7)

When the average of the data obtained for each algorithm is compared, the linear (775 ms) is the overall best algorithm, if measured against the criteria of quality, reliability, accuracy and repeatability.

It was therefore concluded to use this specific algorithm for solving the posed hypothesis for various other printouts both from importing from an external source as well as creating one’s own images. (Refer to the Journal file, for examples of these printouts).

# Discussion:

There were various modifications made to the algorithm and printer including:

* Changing the x – axis movement system of the printer.
* Adding a piece to decrease the amount by which the pen can “wobble”.
* Changing the GUI Layout to be more user friendly.
* Changing GUI look to be more visually appealing.
* Changing the printing speed of the printer to print faster.
* Changing the algorithm that sorts all the points that need to be drawn to decrease movements printer needs to execute.

In the end the algorithm that is chosen will largely be influenced by the things that the possible users of the product find important. Since the possible users did not indicate speed as being a top priority but rather chose quality as being more important, the final algorithm will focus more on quality than time.

## Anomalies:

The software sometimes does not transmit the data to the printer fast enough. This results in a run time error occurring in the software.

## Limitations:

The maximum print size that the algorithm can currently print is on a paper size 126 x 181 (portrait) and 181 x 126 (landscape). This size can however be changed later if needed. The reason for choosing this specific sized image is due to the current A5 size page holder. The empty frame around this spot, the program considers and thus ensure that the printer does not print over the sides of the A5.

# Conclusion:

Through testing various algorithms, it was shown that it is possible to write a reliable and working algorithm to covert digital images into instructions that can be transmitted to a DIY printer for printing physical 2 D images. Even though it does have some limitations regarding speed and printing quality, the algorithm can successfully functions as was intended and the hypothesis could be proven successfully.

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