

# Generation of automatic stippling illustrations from photographs for documenting archaeological pieces

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## Resumen

*El punteado manual se ha utilizado frecuentemente en el proceso de ilustración para documentar piezas arqueológicas. Esto se debe a que esta técnica es capaz de representar de forma eficiente formas, tonalidades y texturas mediante la distribución de puntos en un papel. Estas ilustraciones requieren las habilidades de un artista, el cual utiliza fotografías para realizarlas. En este artículo se presenta un software que genera ilustraciones punteadas de alta calidad de forma automática. La interfaz desarrollada hace posible que cualquier usuario pueda generar ilustraciones sin la necesidad de habilidades artísticas. El programa trabaja en tiempo real permitiendo al usuario interactuar con el mismo. Hemos implementado varias técnicas empleadas por artistas como simples tareas de alto nivel que mejoran los resultados finales.*

**Palabras Clave:** ILUSTRACIÓN AUTOMÁTICA, DOCUMENTACIÓN ARQUEOLÓGICA, TÉCNICA DE PUNTEADO, INTERFAZ GRÁFICA

## Abstract

*Hand-made stippling has been used frequently in the process of drawing illustrations for documenting archaeological pieces. This is due to the fact that this technique represents in an efficient way shapes, tones, and textures, by means of distributing dots on the paper. The process of stippling has needed traditionally the ability of an artist, who usually produces the illustration from photographs. In this paper, a program that generates stippling illustrations of high quality is presented. The developed interface makes possible that any user can generate illustrations without the need of artistic abilities. The program is able to work in real-time, allowing the user interacts with the program. We have developed several artistic techniques in high level tasks that allow to improve the final results.*

**Key words:** AUTOMATIC ILLUSTRATION, ARCHAEOLOGICAL DOCUMENTATION, STIPPLING, GRAPHIC USER INTERFACE

## 1. INTRODUCTION

Documenting archaeological pieces is a complex task that requires both an artist and an archaeologist. This is due to the fact that artists usually do not know what parts are more relevant in the pieces. Stippling is a very used technique due to the possibility of simplify the model without losing details. Stippling is a pen-and-ink technique based on using small dots to represent the shape, tone and texture. This technique must not be confused with half-toning. Images produced by half-toning or dithering and computer printers operate on similar principles. However, half-toning is not able to produce illustrations for documenting archaeological pieces due to the lack of artistic abstraction.

Previous techniques have severe problems with dots, all the previous techniques use black dots or geometric shapes for the dots, whereas traditional stippling produces irregular grey-scale dots. They have also problems when producing tonal ranges due to the fact that dots they use are black. With respect to the first problem, most of the techniques do not simulate the dots correctly or they scan the dots from original illustrations which is a tedious process and produces repetitive dots.

Concerning to the second problem, previous techniques have a problem overlapping the dots on the paper when simulate gradients of tone, mainly due to the fact that dots are black or white in all the process, producing an strange overlapping or patterns. Previous techniques do not allow interaction with the user because they use expensive algorithms that require a lot of time to produce the final illustrations.

In this paper we propose a software that solves these problems. The method works in real time, this allows to have an user interface that can modify these aspects. This system do not require the ability of an artist because any user can use the tool to obtain the desire result.

## 2. RELATED WORKS

There are many works related with automatic stippling. We are specially interested in methods that produce stippled images from 2D images and photographs. Among these methods, Secord (SECORD 2002), Deussen (DEUSSEN 2000), Hiller (HILLER 2003), Dalal (DALAL 2006), Barla (BARLA 2006) and (SECORD 2002), use centroidal Voronoi diagrams (CVD) to distribute the dots. Their approach has problems with

patterns. Schlechtweg (SCHLECHTWEG 2005) uses a multiagent system called Renderbots, to position different kinds of drawing primitives. The main problem is that in the borders of the tiles it produces errors that must be corrected and the dots are black circles or another geometrical shape. Mould (MOULD 2007) creates a weighted graph that controls the location of dots, its results show the alignment of the dots on the edges, which is disturbing. Kim (KIM 2009) provides a method for extracting a tone map and dots from the original image, the method is complex and it only works with black dots, being unrealistic. The work of Isenberg (ISENBERG 2005) and the works of Maciejewski (MACIEJEWSKI 2008) show a guide of differences between automatic and hand-drawn stippling.

### 3. OVERVIEW OF THE SYSTEM

The system we propose takes an image as input. The image is analysed and processed. Then a statistical function is built using the obtained information. A set of dots are placed on the image. By means of an user interface, the user can alter the way the dots are placed on the paper and the shape of these dots. The core of our system uses three main algorithms:

- The extraction algorithm (EA): take the input photograph and transform it enhancing its contrast and its borders. It also processes the information of the frequency of the luminance in the image. This allow to obtain the interesting areas.
- The dots placement algorithm (DPA): this algorithm places the dot according to a statistical function obtained from the information given by the EA. This algorithm prevents patterns that make the final illustration easily distinguishable as computer generated.
- The algorithm of dot generation (DGA): once a position is given by the DPA, the DGA create a new dot with the information extracted by the EA in that position. This dot is generated by simulating the process of ink-spreading on the paper, so it produces realistic and not completely black dots.

### 4. THE USER INTERFACE

The user interface displays the information of where dots will be placed by means of a mask. This mask shows not only the density of the dots, but also the priority of what dots will be placed first and what will be their size and spacing. All this information can be shown using only one RGB image.

The user can enable a menu that allows altering the mask and, therefore, the illustration may change its appearance. This menu has a set of operations. Any operation changes the tool and allows the user paint on the mask. These tools simulate some of the most important techniques used by artists when stippling illustrations.

The tools of the menu are:

1. Remove: allows to remove the data of the painted area of the mask.

2. Redraw: resets the data in the painted area of the mask.
3. Draw First/Later: changes the priority of the stippling in given area of the mask. It allows the user selects what areas are more/less important in the illustration.
4. Enhance borders: enhance the borders of the image by stippling only the sharp parts of the area in the illustration. It is interesting to enhance details of the illustration.
5. Shade: adds some shade to the area, enhancing details, shades and shadows.
6. Invert: inverts the brightness of the image in the painted area. It enhances the details of low contrasted areas.
7. Stop stippling: stops stippling in that area. The algorithm continues stippling in the rest of the illustration, or it stops definitely if the whole area was painted.
8. Continue stippling: continue the stippling process in an area.
9. Change the distance between / size of dots: change the distance and size of the dots according to the level of contrast in the image. It is not a tool used very often but may be useful when the automatic process does not work properly.

In Figure [1], an example of the effect of these tools is shown:

- a. The user can view the default mask that corresponds to the statistical function (darker areas have more probability than lighter areas, the green value indicates the size of the dots).
- b. The user uses the remove tool to eliminate all but the top part of the vessel, then only the rest of areas are stippled by default.
- c. The user uses the redraw tool on the vessel, so the algorithm stipples this area again (note how the operation does not produce patterns and the transition of the dots is smooth).
- d. The operation of stippling before or stippling later changes the mask, darkening or lightening the areas.
- e. The borders tool has been used in all the vessel, removing the dots and changing the mask, so the algorithm only stipples in the borders.
- f. The shade tool is applied in a part of the vessel, so the shade is highly improved whereas the borders of the previous steps are maintained.
- g. Continue/stop stippling tool allows to stipple only some areas of the image. It can also enhance the details of an area.
- h. The size and the space between dots can be changed with the appropriate tool in a part of the vessel.
- i. The inversion tool allows to change the way the stippling is produced. This tool has been applied to the entire image. This tool must be used carefully because in real illustrations artists only use it when a lot of dots hide the details

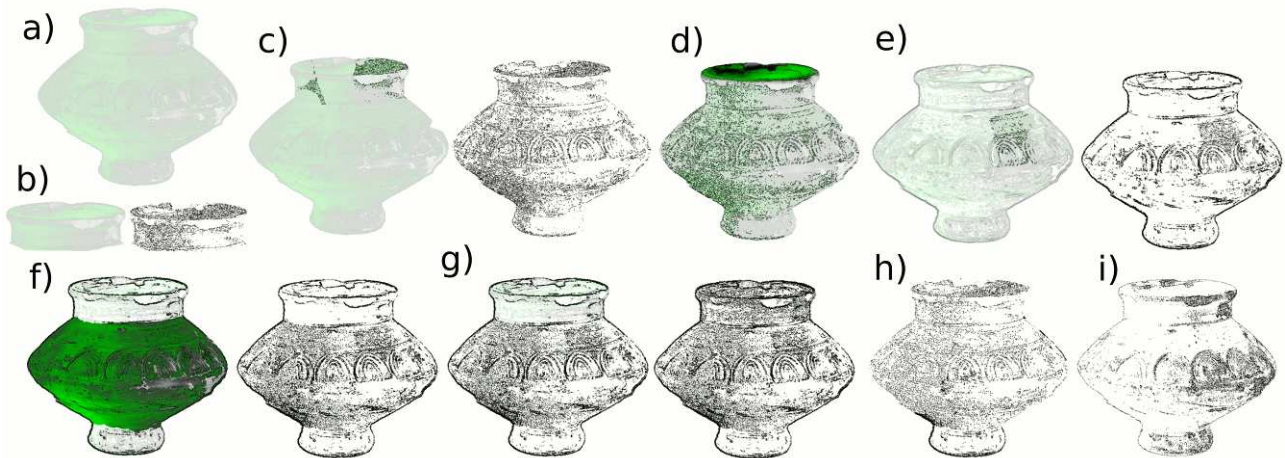


Figure 1: Effect produced by using different tools applied in order from a) to i).

## 5. THE SOFTWARE

The developed software runs in the most important operative systems: any version of MS Windows, Mac OS X Leopard, any version of Linux, and FreeBSD.

The software has an user interface that allows to select the photograph from a folder in the system, it allows to select the type of paper and its absorption (this is needed only to process the shape of the dots). We can also choose the size of the technical pen, and the size of the final illustration. These elements are shown in Figure [2].

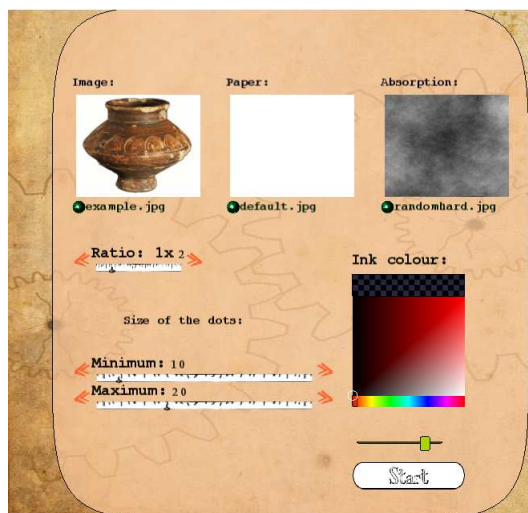


Figure 2: Screenshot of the first step of the main interface.

When the start button is pressed the user interface changes, and it shows a play/stop button, a show/hide mask button, a save illustration button, and a menu button with the tools shown in Section 4. These buttons allow to start/stop the application and

to save the illustration in any moment, even if it is not finished yet (it is useful to obtain an unfinished look appearance in the illustration).

We can also stop the stippling in order to better handle the tools to alter the illustration.

## 6. RESULTS

The system works in a simple laptop with a digital tablet, as shown in Figure [3]. In this figure, we can see how painting on the right size of the mask and using the shade tool, the detail of the medallion is improved. We have tested the accuracy of the generated dots, these dots can be compared with dots of a real illustration, as shown in Figure [4]. Using the different tools the pieces can obtain the desired level of detail, as shown in Figures [5], [6] and [7]. The required time to learn the tool is very small, just between 10 and 15 minutes. The needed time to produce an illustration once the user has been trained is between 2 minutes and 10 minutes. If we compare the required time for the artist to draw the same illustration, the system is very fast. Usually, an artist requires near to 48 hours to finish a stippled illustration.



Figure 3: Photograph of the laptop with the system on the left; the user has painted on the right part of the mask applying a shade tool.

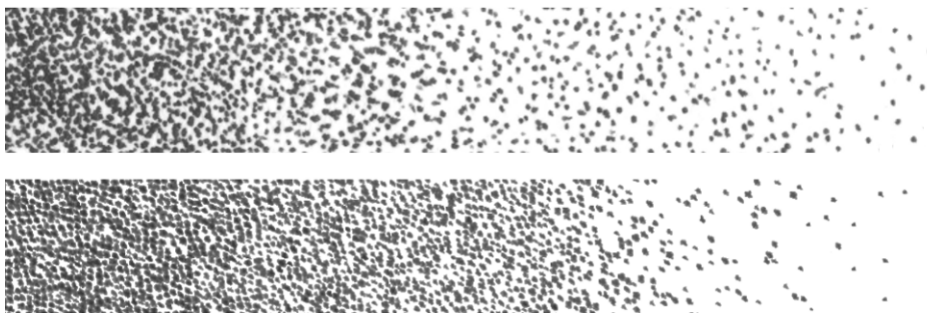


Figure 4: Real tonal range drawn by an artist on the top; tonal range obtained with our software on the bottom.

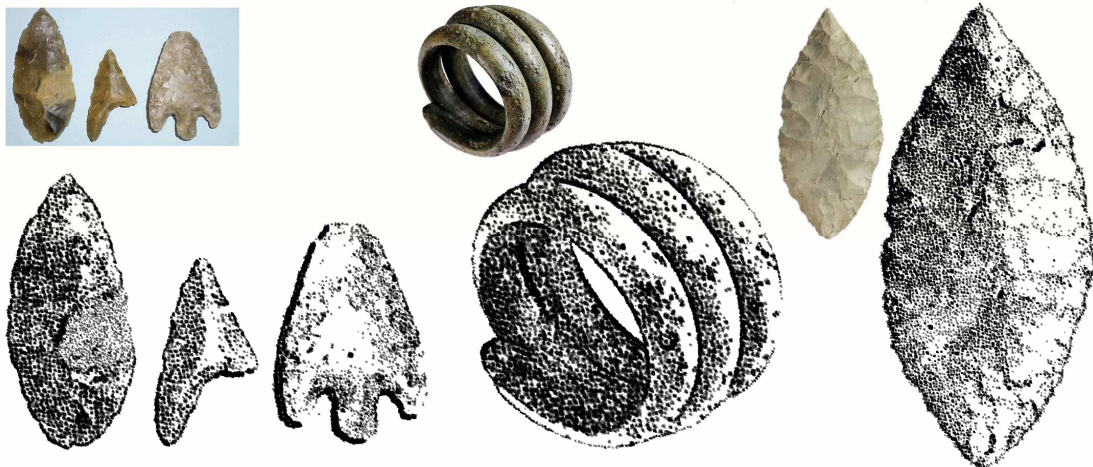


Figure 5: Illustrations of very different pieces obtained with our software. All the illustrations have been produced in less than 5 minutes of user interaction. The user was previously trained in the system in the previous 15 minutes.



Figure 6: Different illustrations of pottery. All the illustrations have been stippled using the enhancing borders tool and the shading tool exclusively.

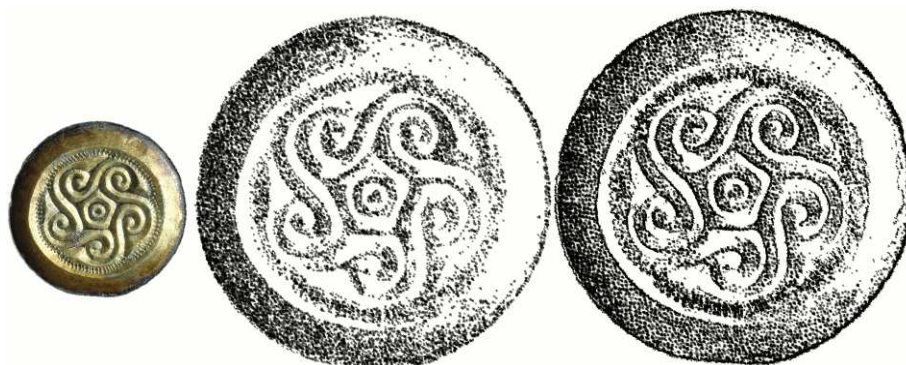


Figure 7: By default the system is able of stippling (on the middle) the photograph on the left; but if the user uses the tools, results can be improved (on the right).

## 7. CONCLUSIONS

In this paper, we have presented a program to generate automatic stippled illustrations. The dots are synthetically generated by the algorithms and they are almost identical to the dots generated by artists when they stipple illustrations. The presented algorithm uses an iterative stochastic method to generate the dots. The parameters of the algorithm can be easily defined by the user by painting on a mask and the user interface.

We have also presented a tool that automatically generates stippling illustrations. This software can generate very realistic illustrations with dots of different shapes and sizes. The user interface allows the user to modify any part of the mask and to apply some of the common techniques used in traditional stippling in a easy way. This is done by painting on a simple mask that affects to the probabilities to place the dots and the information extracted from the photograph.

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