BODIES3D.EXE: AN AID FOR THE DISPLAY OF 3D ROTATABLE IMAGES OF HUMAN AND ANIMAL BODIES IN GRAVES

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This package is written to run on 32-bit and 64-bit Windows operating systems. It may also run on Macs, under *Parallels Desktop* 7.[1]

> *Before proceeding, please read the section on COPYRIGHT AND CONDITIONS OF USE on page 17 of these notes.*
>
> *Please also send me an email, so that I can put you on a list for notifying updates.*
>
> *For summary advice on how to get going, read the section on page 11.*

PRELIMINARY DEMONSTRATION

Before continuing with the technical instructions, you may wish to have a look at some results produced by the package Bodies3D.

To view rotatable representations of human bodies, take the steps listed below.

Run Lines3D.EXE. Open a ROT file. Note that within the window of Lines3D, and having opened a ROT file:

> rotate the image by using the keyboard arrows or by dragging with the mouse.
>
> you can switch off the 'Fade' box (I find it preferable to switch it off)
>
> to see through a head, to what is behind, untick the box 'Fill circles'.
>
> after rotation, return to the original image by clicking on the box 'Center'

[1] http://www.parallels.com/products/

Take the following steps to rotate the demonstrations:

1. Run the program Lines3D.EXE.

2. Open the file Demo1.ROT - a rotatable human figure.

3. Open the file Demo2.ROT - eight rotatable bodies in a shared grave. The image shows the top of the grave (green) and the base (black). There are also three artefacts represented as small red circles.

4. Open the file Demo3.ROT - a mass grave, with the position of a particular body highlighted in red.

5. Open the file Demo4.ROT - a rotatable kangaroo figure.

GENERAL INTRODUCTION

Visual 3D display

Suppose you have surveyed data for bodies in three dimensional space, i.e. Eastings, Northings and Elevations.

You want to represent these bodies in three dimensional space, and not merely as a map looking from above. You must therefore be able to rotate the image to look at the distribution of the bodies from any position. Are there, for instance, a plane of view that is empty of bodies, and which therefore separates them into distinct layers? Or are there heaps of bodies, consistent with being dumped into a mass grave by trucks.

Evidentiary requirements

You also want to send such three dimensional data to a client, in such a format that the client can also view the bodies in three dimensional space. It happens that the client does not have any special computer literacy or GIS/CAD software?

The program Bodies3D.EXE provides a solution to both the visual and evidentiary requirements.

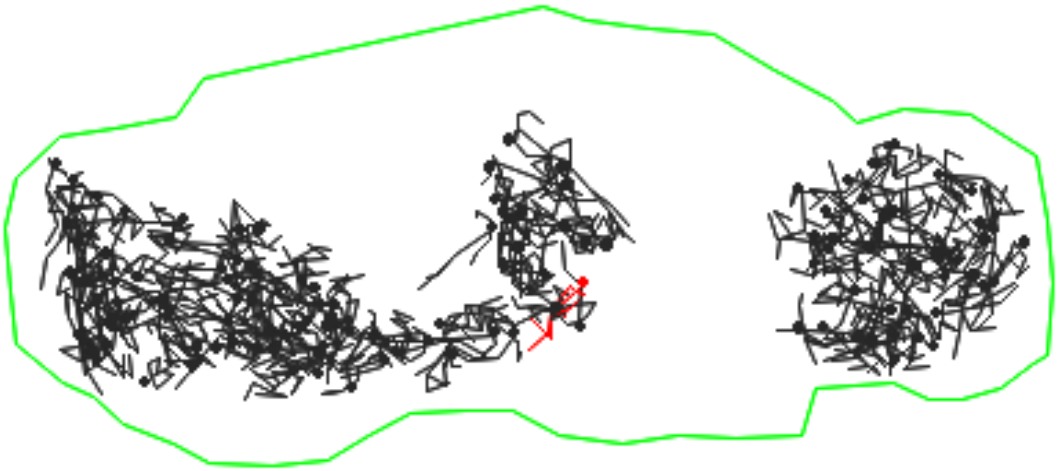
The solution is to show bodies as stick figures in graves, using the simple and freely distributable software of the package Bodies3D. In other words, you send the data and the software for viewing the data.

Comparison of 2D and 3D representation

Two dimensional display of bodies requires no special explanation.

In the next illustration, Here we are looking down on bodies in a mass grave. This is the standard manner in which 2D archaeological maps are published. This is the standard way in which evidentiary images are transmitted.

However the bodies represented on such a map are in fact suspended in vertical space - they are in 3D space. Representing them merely in 2D space wastes spatial information.

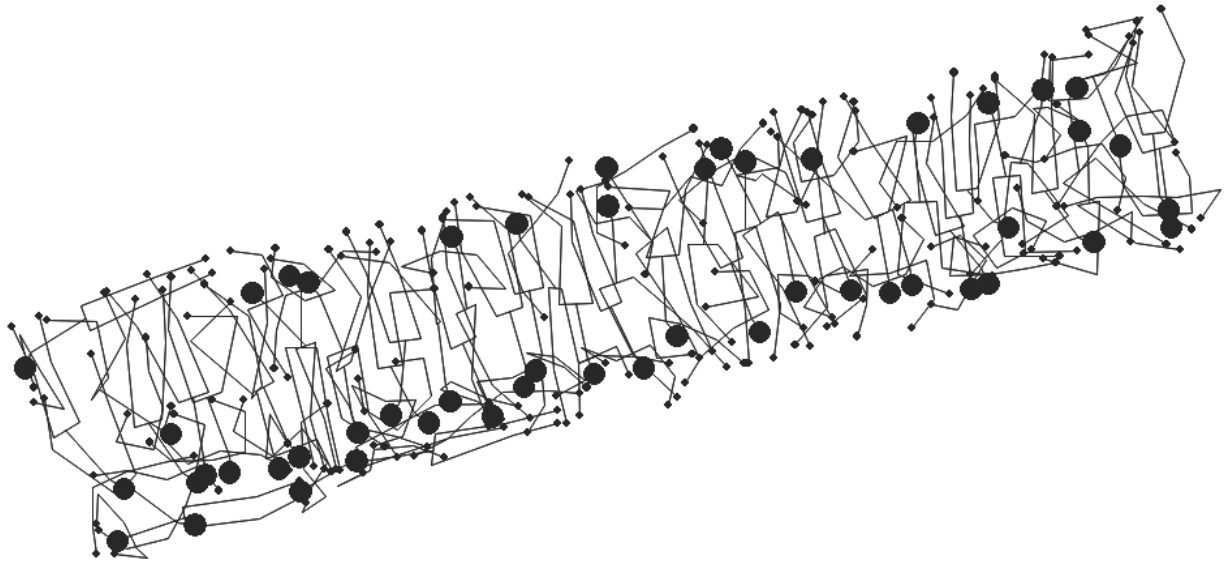


Suppose we want to rotate the bodies in 3D space, so that we can look into the grave from various positions around the grave's side. The image must be rotated on a computer screen, to look for distributional pattern from all possible directions.

The next example illustrates the results of rotation. It is based on a survey of XYZ coordinates. The survey was done by Oxford Archaeology. The site is one of the WW1 mass graves at Fromelles in NE France.[2]

The upper part of the illustration shows a standard 2D representation in plan.

[2] Oxford Archaeology also used its software CrossBones.



Suppose we want to see these bodies in section, i.e. a view looking at the bodies sideways on. As archaeologists will understand, such a view can only be reconstructed from survey data, because the upper bodies had to be removed before the lower bodies could be removed.

A view from the side can be readily generated by Bodies3D using the auxiliary program Lines3D:

Now we can clearly see a separation between a lower and an upper layer of bodies.

The needs of colleagues and clients

How is the data for a 3D image, together with a method of viewing, to be sent to a colleague or client?

Clearly one cannot expect the client to install expensive GIS/CAD software, where the client needs training before being able to use it. Some simple solution is required.

A solution using Bodies3D and lines3D

The program Bodies3D.EXE, together with Peter Bone's freely distributable program Lines3D.EXE, makes

transmission of 3D rotatable data, and use by a client, sufficiently simple.[3]

The client will be immediately able to rotate the objects suspended in 3D space, and then distribute the package to an indefinite number of third parties.

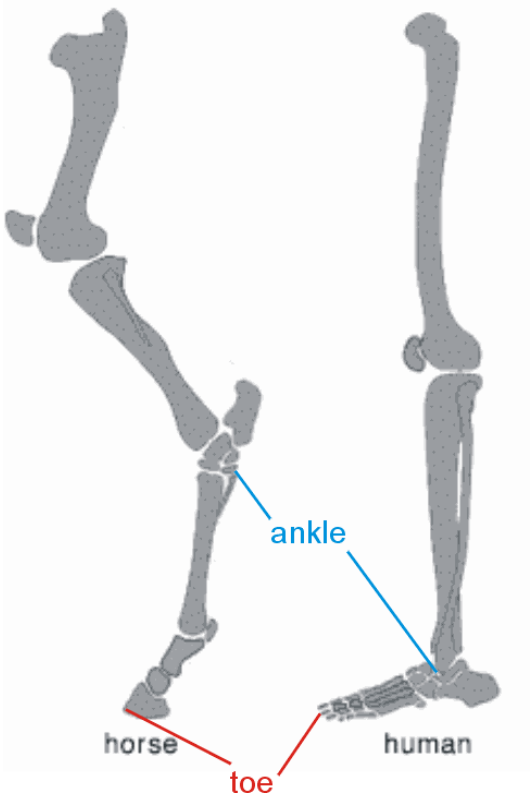
HUMANS AND OTHER ANIMALS

Representation of humans in mass graves is the historical origin of the program Bones3D.EXE.

However the program is now elaborated to cater for animals. The major additional anatomical requirements for most animals are obviously these.

1. The tail.

2. The frequent need to increase distance at the ends of the limbs.



We may need to represent not only the wrist and ankle (which effectively substitute for each other in the case of humans, given the

[3] For Lines3D, visit Peter Bone's entertaining web site http://pbone.it-mate.co.uk/index.html

resolution of the stick figures), but also the ends of the forelimbs and hindlimbs.

As the above diagram shows, the distance between the ankle and the toe is minor in humans but major in the horse.

ADEQUACY OF STICK FIGURES

Why merely use stick figures? It might be thought that 3D computer graphics would be improved by rendering the figures, to include covering of flesh and clothes.

On the contrary, rendering would defeat the purpose of a program such as Bones3D. To see structure in the arrangement of bodies in a grave, it is necessary to see through a body in the foreground to envisage those beyond.

Stick figures provide minimal visual blockage of bodies that lie beyond the ones at the front of the screen. Rendered figures would provide maximum visual blockage.

So stick figures are not only adequate - they are essential for analysis of patterns within mass graves.

HISTORY OF BODIES3D.EXE

The program Bodies3D.EXE adopts a minimalist approach to representing rotatable 3D images of bodies in a grave. It is based on a system developed during the exhumation of mass graves in Bosnia between 1997 and 2000, and which has been presented in reports to ICTY and reviewed in testimony to the courts of ICTY.[4]

Some readers may remember my previous package called BODROTA. That was clumsy to navigate, and used a program for rotation that was much inferior to Lines3D.

Originally the package used the DOS utility program ROTATE written by Marijke van Gans. This was a leader in its day. Then Peter Bone generously agreed to rewrite ROTATE to run under Windows. His program is Lines3D.EXE. The latest version, at this date, is 1.4 dated 15/04/09. It is included with this package.

[4] E.g. in 2011, in the case against Radovan Karadzic. http://www.icty.org/x/cases/karadzic/trans/en/111201IT.htm Page 22282

Note that the files produced by my program Bodies3D will run on Lines3D version 1.4, but not on earlier versions.

MORE REASONS FOR HAVING ROTATABLE IMAGES OF BODIES IN GRAVES

Bodies in graves are sometimes distributed in an orderly manner. Yet in many graves, bodies are multi-layered and distributed in three-dimensional chaos. Bodies are in a particular tangle if they have been bulldozed into a grave.

This chaos may leave a deep mental impression on the exhumers untangling the remains. Unfortunately, such a vivid memory in 3D is not amenable to direct visual representation. Periodically taken photos and sketches offer some help if they provide a succession of 2D images from a single viewpoint. Yet they cannot be stitched together into a single image that shows the 3D complexity.

What is more, bodies are often removed one by one, as soon as each is uncovered. This removal on discovery is often necessary because mass graves require procedures that conserve soft tissues from further putrefaction. Even if putrefaction is not a problem, upper bodies must be removed before lower ones can be processed.

To sum up, procedures at multi-layered mass graves differ from the standard archaeological approach to the exposure of skeletonised remains in cemeteries. Cemeteries are usually 2D for the purposes of illustrative display. Skeletons can normally be left in place until a sufficient area is uncovered for a 2D sketch or photo.

Such a sketch or photo is adequate for most cemeteries. No such sketch or photo is possible for multi-layered mass graves.

Here are some possible needs for 3D rotatable representation, each of which applied to my forensic work in Ukraine and the former Yugoslavia:

- showing that the method of disposal of bodies was orderly or disorderly, as the case may be;

- showing episodic disposal of bodies, evidenced by, for example, partial back-filling of a grave between disposal events - leading to separation between layers of bodies;

searching for the shape of clusters of bodies, and the arrangement of bodies within these clusters - observations that may show disposal methods such as bulldozing a mass of bodies to the end of a trench or dumping batches of bodies from trucks;

demonstrating that shell cases, and other objects, are uniformly or non-uniformly distributed among the bodies;

where there has been destructive tampering with a grave, with partial removal of bodies, showing the association of left-over body parts, as distinct from complete bodies, with stratigraphically recognised robbing events that intrude into the original grave.

BODIES3D - HUMAN AND OTHER ANIMAL BODIES

The human body

Following on from the Bosnian forensic work, the 13 points for human bodies are listed on page 224 of the book by Margaret Cox and others - *The Scientific Investigation of Mass Graves* (2008).

The anatomical points on the human body are still the same for Bodies3D, but the list on page 224 of the above book offers different labels for two of these points. These two labels are not compatible with Bodies3D.EXE - these are PELL and PELR. For Bodies3D use LPEL and RPEL respectively - labels that were earlier used in BODROTA.

The anatomical meaning of the 13 four character labels is as follows. Note that the ultimate resolution by stick figures means that the user need not be too fussy about anatomical exactitude when surveying:

CRAN	cranium (central)
RSHO	right shoulder
RELB	right elbow
RWRI	right wrist (area of carpal bones)
LSHO	left shoulder
LELB	left elbow
LWRI	left wrist (area of carpal bones)
RPEL	right pelvis (greater trochanter of femur)[5]
RKNE	right knee

[5] If you have a legless torso, then for LPEL and RPEL you estimate the position of the greater trochanter of the femur.

RANK	right ankle (area of talus bone)
LPEL	left pelvis (greater trochanter of femur)
LKNE	left knee
LANK	left ankle (area of talus bone)

The animal body

For an animal body, Bodies3D.EXE uses all the points given above for a human body. As well (and using anthropomorphic anatomical terms) most animals need:

RFNG	right finger (tip)
LFNG	left finger (tip)
RTOE	right toe (tip)
LTOE	left toe (tip)
TAIL	tip

Forms

Details of how to use the program Bodies3D.EXE are given below. The program works with one body at a time. For a mass grave, the user pastes the output from each use of Bodies3D into an accumulating meta-file for the mass grave (see below, for more explanation of this procedure).

There are two spreadsheet forms that the user fills in - one for a human body and one for an animal:

FormHum.CSV

FormAnim.CSV

If the grave contains both humans and animals, then the output from Bodies3D can be pasted into the same meta-file for the mass grave - regardless of whether the input comes from FormHum.CSV or FormAnim.CSV.

For automated processing by Bodies3D.EXE, a body (whether human or animal) must have, as a minimum, 3D coordinates for a cranium and torso, namely CRAN, LSHO, RSHO, LPEL and RPEL.

Because of the schematic stick figure representations of Bodies3D, it is possible to identify what limbs are represented only by reference to a cranium and torso: the head serves as a prompt to the orientation of the body.

If wanted, isolated skulls and limbs can be written manually into the output of Bodies3D (see below, under *Adding Features to the Map of Bodies)*.

SUMMARY ADVICE ON HOW TO GET RESULTS FROM PROGRAM BODIES3D.EXE[6]

Put the downloaded file Bodies3D.ZIP into a folder of your own choosing (let us say C:\Bodies. Unzip it there.

Put the file Lines3D.ZIP in the same folder, and unzip it.

No other installation is needed. All operations will be carried out within this folder.

To get a result for an individual set of 13 surveyed body points (for definitions, see page 9) you take the following steps.

(1) Copy and paste the northings, eastings and elevations for the body into the file FormHum.CSV (or FormAnim.CSV if animal).[7]

(2) Save the result twice as a CSV file - first as BodyXYZ.CSV and then as an archival file with a name of your own choice, say Body031.CSV. The reason for doing this double save is that the file BodyXYZ.CSV will be overwritten on further use, and you will probably want to archive the surveyed points for each body.

Microsoft have not made saving CSV files intuitively simple.

If you are asked whether you want to replace the existing file BodyXYZ.CSV then answer 'Yes'.

If you are asked a question about whether your want to keep possibly incompatible features then answer 'Yes'.

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[6] To avoid repetition, this advice refers to procedures for a human body entered via the spreadsheet file FormHum.CSV. The same general procedures are followed for animals, but using the spreadsheet file FormAnim.CSV.

[7] Both Bodies3D.EXE and Lines3D.EXE accept double precision numbers. This means that full coordinates can be pasted in for a GPS eastings and northings. For example, to the nearest centimetre a full northing for the southern hemisphere may be 10000567.24.

When you exit Excel you may be asked whether you want to save the changes made to BodyXYZ.CSV. Answer 'No'.

[Here substitute label of body]			
point	easting	northing	elevation
CRAN			
RSHO			
RELB			
RWRI			
LSHO			
LELB			
LWRI			
RPEL			
RKNE			
RANK			
LPEL			
LKNE			
LANK			

(3) Above is an illustration of the file FormHum.CSV, before it has been filled in. You will substitute the label of your body into the top left cell. You will then type or paste the coordinates into the three columns under easting, northing and elevation.

Below is an example of a filled in form FormHum.CSV, ready to be saved as BodyXYZ.CSV.

Skeleton030			
point	easting	northing	elevation
CRAN	147.899	230.306	97.156
RSHO	148.043	230.079	97.119
RELB	148.339	230.018	97.028
RWRI	148.381	230.195	96.908
LSHO	148.112	230.244	96.998
LELB	148.265	230.46	96.849
LWRI	148.158	230.645	96.892
RPEL	148.484	229.961	96.971
RKNE	148.779	230.178	97.098
RANK	148.844	229.887	96.814
LPEL	148.424	230.139	96.85
LKNE	148.968	230.211	96.954
LANK	149.148	229.822	96.833

(4) Run the program Bodies3D.EXE, which generates a 3D text file readable by Lines3D. The file name is 3D-BODY.ROT.

(5) If the program Bodies3D.EXE reports no errors, then open Lines3D.EXE, and rotate the body of the generated file 3D_BODY.ROT.

(6) If you want to combine further bodies with the body you are working on, then

open the file 3D_BODY.ROT with a plain text editor such as NotePad;

likewise open the file Archive.ROT, and save it to a new file name of your choice, say *Porterhouse Cemetery.ROT*.

(7) Copy from 3D_BODY.ROT only the label of the body, and all 20 lines of its data - i.e. not the seven opening lines:

For example, copy:

```
#Skeleton030
 147.99   97.11   230.23  -7
 147.99   97.11   230.23  0
 148.08   97.06   230.16  7
 148.45   96.91   230.05  7
 148.11   97   230.24  0
 148.04   97.12   230.08  7
 148.42   96.85   230.14  0
 148.48   96.97   229.96  7
 148.11   97   230.24  0
 148.26   96.85   230.46  7
 148.16   96.89   230.65   7
 147.9   97.16   230.31   0
 148.04   97.12   230.08  0
 148.34   97.03   230.02  7
 148.38   96.91   230.2   7
 147.9   97.16   230.31   0
 148.42   96.85   230.14  0
 148.97   96.95   230.21  7
 149.15   96.83   229.82   7
 147.9   97.16   230.31   0
 148.48   96.97   229.96  0
 148.78   97.1   230.18  7
 148.84   96.81   229.89   7
 147.9   97.16   230.31   0
 148.45   96.91   230.05  0
 147.9   97.16   230.31   0
s CircleDiameter 0.03
 148.38   96.91   230.2 -7
 148.16   96.89   230.65 -7
 148.84   96.81   229.89 -7
 149.15   96.83   229.82 -7
```

Append, by pasting the lines into the new ROT meta-file that you are working on.

(8) Repeat this operation for the next body you process, pasting its data below the previous one in the archive ROT file.

(9) The prior notes have assumed that the body has a complete set of 13 points. However, Bodies3D.EXE caters for incomplete bodies provided the cranium and trunk are present, i.e. points CRAN, RSHO, LSHO, RPEL and LPEL.

To enter data for incomplete bodies:

Enter whatever points are available into *Form.CSV.* Note, as explained before, you must have coordinates for CRAN, RSHO, LSHO, RPEL and LPEL.

Delete the rows for which there are no coordinates.

Here is an entry for an incomplete body, before saving as BodyXYZ.CSV. Note how lines with no coordinates are deleted.

Skeleton030			
point	easting	northing	elevation
CRAN	147.899	230.306	97.156
RSHO	148.043	230.079	97.119
LSHO	148.112	230.244	96.998
RPEL	148.484	229.961	96.971
RKNE	148.779	230.178	97.098
RANK	148.844	229.887	96.814

This individual has only a cranium, torso, and a right leg.

Because Lines3D.exe can display each body individually, you can check its integrity before it is entered into the grave's archival meta-file that has the data for all bodies. You might for instance find that an ankle, thought to belong to one body, was wrongly entered with another. In this case your

display of the body might show an anatomically impossible stretched leg. What is to be done? A possible solution is to approximate the 3D XYZ coordinates for the ankle by examining a photograph or sketch of the body.

If a question arises about the location and disposition of a particular body in a grave, then you can edit the archive text file to highlight the particular body by changing its colour. See Peter Bone's file ReadMe.TXT for a statement about colours and their number codes.

If portraying animals, and the circle for the head looks too large, experiment with altering the line near the top of the ROT file from the default *s CircleDiameter 0.17* to *s CircleDiameter 0.10*. Increase the value if the head looks too small.

ADDING FEATURES TO THE MAP OF BODIES

ROT files, generated by Bodies3D, are plain text files. You can therefore add text to the ROT files manually.

The ReadMe.txt file of Peter Bone's Lines3D gives general instructions for editing a ROT file, and you may need to consult those instructions to understand the following advice.

Regarding layout of the images, the convention I have followed is that the opening screen in Lines3D is a view looking down on the bodies, with north at the top of the screen.

To achieve this view, the order of coordinates in a ROT file is Easting, Elevation, and Northing (or XZY).

Following the three coordinates is a single number, representing the colour of the pen. A positive number is used for lines and a negative number for circles.

The basic colour codes are:

1 = red 2 = green 3 = blue 4 = yellow
5 = purple 6 = cyan 7 = white or black depending on black or white background

You can add to the .ROT file such features as:

(1) Surveyed coordinates that show the top and bottom of a grave.

You can use the text of Demo2.ROT file for guidance, if you open it with a text editor such as NotePad.

To show the top or bottom of a grave, follow the format of the coordinates under '#Top of Grave' and '#Bottom Grave'.

Note that:

the hash sign # indicates a remark that Lines3D ignores, but is useful to you as a reminder of what the block of coordinates represents;

the colour 0 moves the pen invisibly to the first set of coordinates;

the coordinates of the final line for the outline (but not the colour) must repeat the first line, so that the feature is closed.

(2) Artefacts can be represented by small circles of differing size and colour.

Again, consult the text of Demo2.ROT.

Write the switch for the circle diameter as shown; this makes the circles smaller than the switch for skulls, which was set initially at 0.17.

The coordinates represent three bullets.

Note that the colour is a minus value, because we are representing circles.

(
3) Body parts, such as isolated skulls or limbs.

The drawing of these is illustrated in the file Demo1aExplanation.ROT.

In that file, explanatory remarks, for your guidance, are preceded by the hash sign.

The file Demo1a.ROT is without these explanatory remarks

ALTERNATIVES TO BODIES3D AND LINES3D

There are sophisticated general purpose programs such as AutoCad™, which can be used to obtain rotatable images. However, they are expensive, and difficult for the novice to use. Even their read-only packages (if available) cannot be casually distributed, installed, and used.

There is also a package dedicated to representation of the human body - CrossBones from Oxford Archaeology, but that requires familiarity withspecialised software.[8]

The target audience for forensic work (lawyers, magistrates, judges, and courts in general) may want to look at the distributional evidence extracted from graves. They may not be computer literate and are unlikely to have 3D rotational programs installed on their laptops.

So preferably, the data and software are contained on a piece of external media, such as CD-ROM, or distributable as email attachments. There must be a simple way of getting the portrayal up and running. I conclude that the big and expensive packages, while excellent for artistic portrayal, do not meet the goal of freely available software designed for looking for patterns of bodies within graves. They do not meet this goal in either sense of the phrase 'freely available'. In other words, the packages are either not *available free of cost* and/or they are not *readily available* outside specialised computer facilities.

The program Bodies3D, together with Lines3D, aims to overcome the impediments of more sophisticated software.

COPYRIGHT AND CONDITIONS OF USE

I keep copyright on the notes and software. However you may, ***without breaching my copyright***, use, copy and distribute the notes and software on the following conditions:

in any report or publication you acknowledge:

[8] See http://oadigital.net/software/xbones.

the author of the program Bodies3D.EXE as Richard Wright with the email address *richwrig@tig.com.au*

the author of the program Lines3D.EXE as Peter Bone, with the email address *peterbone@hotmail.com*

if distributing the package you:

make no charge;

distribute all the package, and not merely selected parts;

include the downloaded and zipped file Bodies3d.ZIP in its unaltered state.

I hope to be able to advise you on problems with the use and results of this free program, but give no undertaking so to do. If you ask for advice, please also attach a copy of any filled in forms and ROT files that you think are problematical.

Users are advised to send their email addresses to me. I like to keep users up to date with any improvements to the package.

I have produced these notes and accompanying software to assist people wanting to create rotatable images of bodies in graves. They are offered free and 'as is'. I have tried to compile the notes and programs by taking every care. However inaccuracies may still occur. These could lead to the user being misinformed or getting wrong results. While regretting the occurrence of any inaccuracy, I cannot accept responsibility for any consequences that may result from that.

FILES IN PACKAGE

When you have unpacked the file Bodies3D.ZIP, the following files will be in the folder.

Archive.ROT
Bodies3D.EXE
Demo1.ROT
Demo1a.ROT
Demo1aExplanation.ROT
Demo2.ROT
Demo3.ROT

Demo4.ROT
FormAnim.CSV
FormHum.CSV
Lines3D.EXE
Lines3D.ZIP
Notes on Bodies3D.PDF [with date of version]
ReadMeFirst.PDF

If at any time one of these files becomes lost or corrupted, then unzip the downloaded file Bodies3D.ZIP again. You will not lose any of your CSV data files.

ACKNOWLEDGMENTS

Sonia Wright helped me with my first primitive attempt at 2D mapping of a mass grave, at Gnivan in Ukraine in 1991. 3D came later - since 1997 in Bosnia, Ian Hanson and Jon Sterenberg have helped with their ongoing interest in developing the 3D mapping of bodies in mass graves. Peter Bone originally wrote Lines3D in response to my request for distributable Windows software; he has always patiently responded to my requests for modifications. Comments by members of the Oxford Archaeology team at Fromelles were helpful in motivating me to rewrite my previous software. Juliet Meyer of the Australian University asked me to broaden the package to cater for animals, and kindly let me distribute, with this package, a demo file of one of her kangaroos.

FINIS.