MANUAL

CRISP: Cremated Remains Inference of Sex Probabilities

V1.0

01/09/2025

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Introduction

This manual delineates the functions of the software program known as CRISP: **C**remated **R**emains **I**nference of **S**ex **P**robabilities. CRISP employs Bayesian modeling to estimate the probability of sex in human cremated remains in an archaeological context. The composition of the sample utilized in the method development and validation process has been documented in Waltenberger et al.[1] CRISP is sheduled to be updated with augmented training sets. Should one wish to offer support for this project by providing datasets for the purpose of refining the software further (e.g., by including models for different populations), one is requested to contact the CRISP team for more information (crisp.helpdesk@gmail.com). Please also report any bugs, and software malfunctions for improvements.

Disclaimer

This software is provided "as is", without warranty of any kind, express or implied, including but not limited to the warranties of merchantability, fitness for a particular purpose and noninfringement. In no event shall the authors be liable for any claim, damages or other liability arising from the use of this software.

The tool is intended for academic and research purposes. It does not replace professional osteological expertise. Users must ensure the correct interpretation and contextualization of the results.

By using this software you accept the terms of this disclaimer.

For updates and maintained versions, please refer to: https://github.com/quadraBits/CRISP

Software Licence: GPL-3.0

Installation

You can download the latest version from https://github.com/quadraBits/CRISP. There you will find the file *CRISP_setup*. Download and install this file in a folder of your choice on your computer. You may need administrative rights to install it. After installation, you can access CRISP by clicking on the desktop icon or the shortcut in the Start menu. To uninstall CRISP, use the uninstall file *unins000*, which you can find in your CRISP installation folder.

Data collection

Measurements need to be taken of complete anatomical structures. Fractured features or estimated distances have the potential to result in an under- or overestimation of the length, which could consequently lead to an inaccurate classification. Fig. 1 provides a comprehensive overview of the landmarks and distances utilized for the software input (from Waltenberger et al.[1]). Measurements should be taken from completely calcined fragments as burnt bones undergo irregular shrinking effects which may affect the results of sex estimation if the bones are not completely calcined. The software only provides a reliable sex estimation for measurements recorded in millimeters.

[1]Waltenberger, L., Beitel, S., Bischeri, M., Rebay-Salisbury, K., Sperduti, A., Cavazzuti, C. (submitted). CRISP: Cremated Remains Inference of Sex Probabilities – A Software for Bayesian Sex Estimation in Human Cremated Remains.

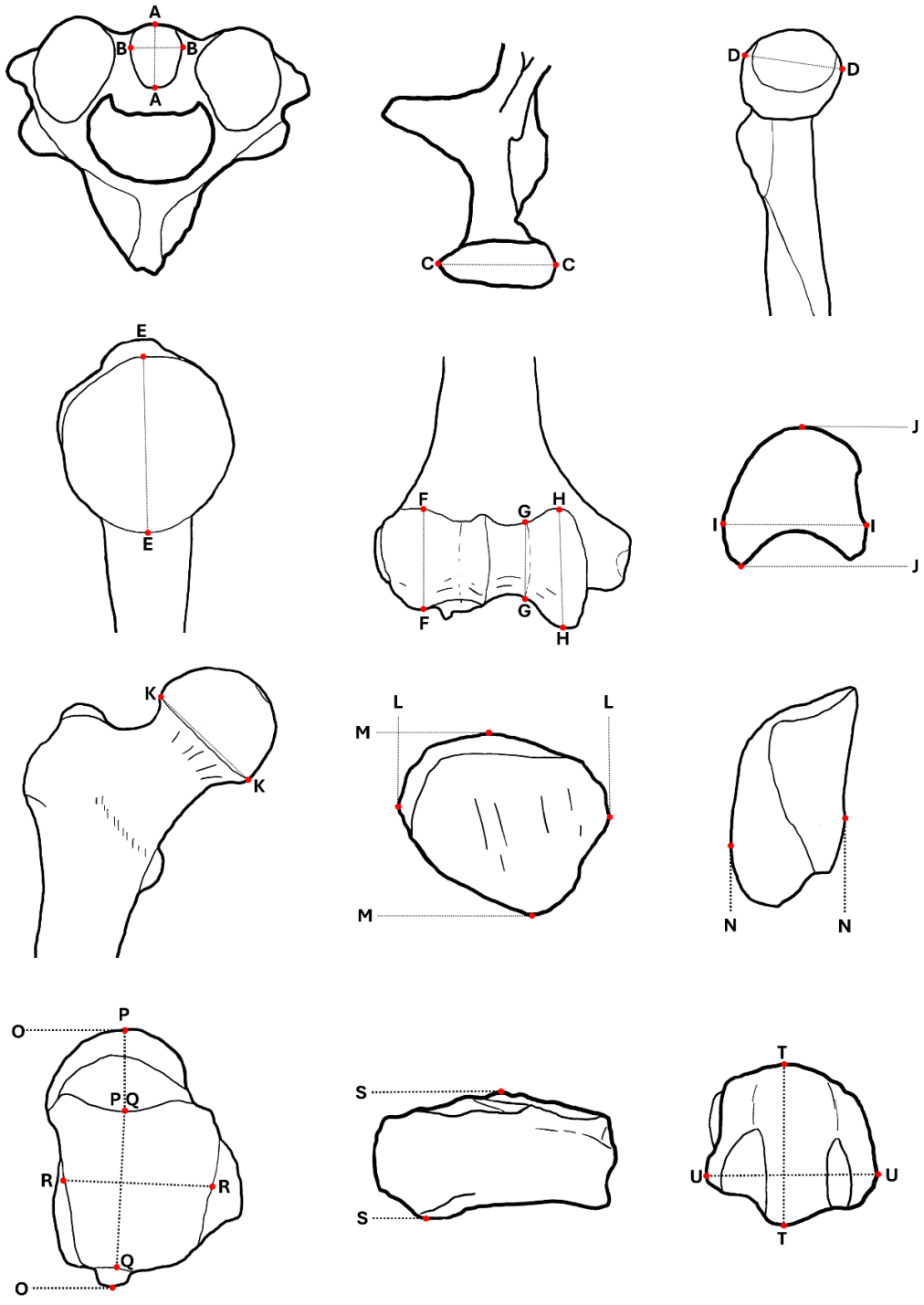


Fig.1: Measurement definitions for all variables: A-A: Axis: ant.-post. Diameter, B-B: Axis: transv. diameter, C-C: Mandible: condyle width, D-D: Radius: max. head diameter, E-E: Humerus: vert. head diameter, F-F: Humerus: capitulum max. diameter, G-G: Humerus: trochlea min. diameter, H-H: Humerus: trochlea max. diameter, I-I: Lunate: max. width, J-J: Lunate: max. length, K-K: Femur: vert. head diameter, L-L: Patella: max. width, M-M: Patella: max. height, N-N: Patella: max. thickness, O-O: Talus: max. length, P-P: Talus: head-neck length, Q-Q: Talus: trochlea length, R-R: Talus: trochlea width, S-S: Navicular: max. length, T-T: MT1: dorsoplantar width of the head, U-U: MT1: med.-lat. width of the head.

Case-by-case-input

In instance where the sex estimation of a particular case needs to be ascertained, the designated form on the data recording page should be utilized (Fig. 2). Please enter all available measurements (in mm). The *Clear Case* button serves to remove the data entered into the Single Case input. The data recording page is equipped with a box on the right side that displays a comprehensive list of all completed tasks, accompanied by pertinent warnings. Warnings assists users to solve issues, that arise when a particular process does not function as anticipated.

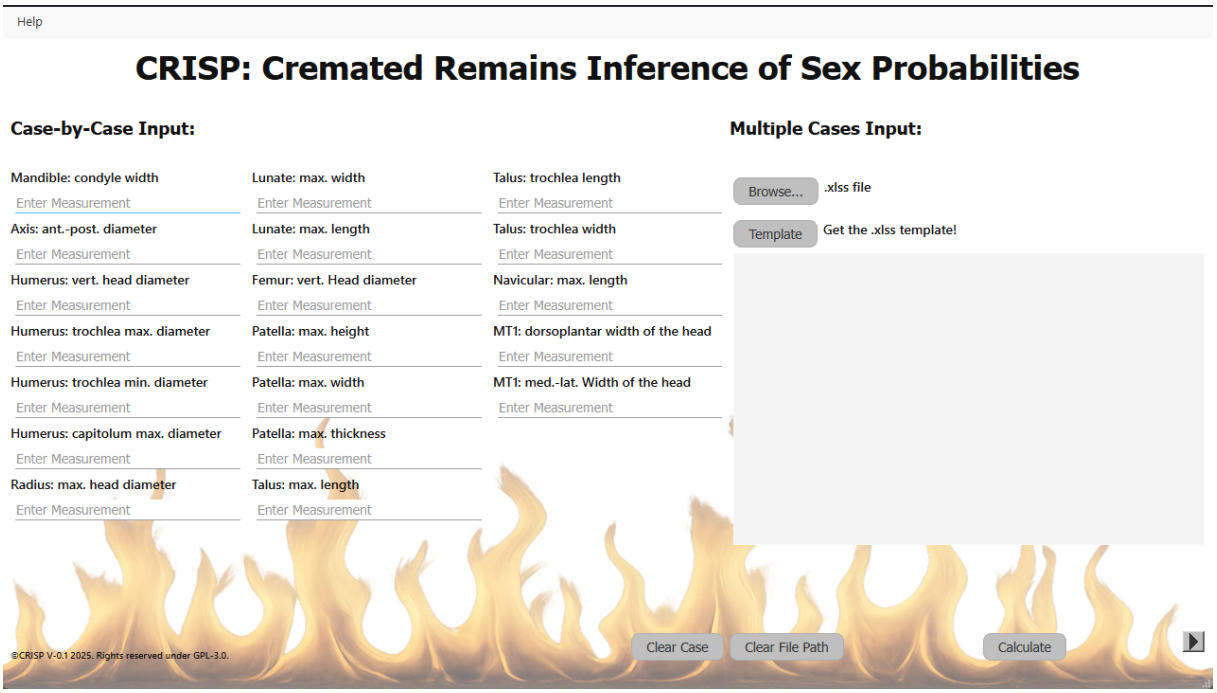


Fig. 2: Main page of the software for data recording. The available measurements for individual cases can be documented in the boxes located on the left side of this page. The estimation of multiple cases can be achieved through the upload of all relevant recordings into an Excel spreadsheet. Please use the provided template (button *template*). The file can be important into CRISP by selecting the *Browse* button. The calculation of the sex prediction is initiated by the act of pressing the designated button.

To initiate the sex estimation process, press the *Calculate*. This action will result in the opening of the results page (Fig. 3). The probabilities of being male or female are located on the right side of the page and are expressed as percentages. Above the probabilities you can find a box for warnings (Please refer to the section “Warnings” for more details). The left side of the results page displays density plots. The distributions for males and females per variable underlying the Bayesian model are represented by probability curves in red (females) and blue (males). Own measurements will be represented by vertical dotted lines within these plots to visualize their location within the data distribution.

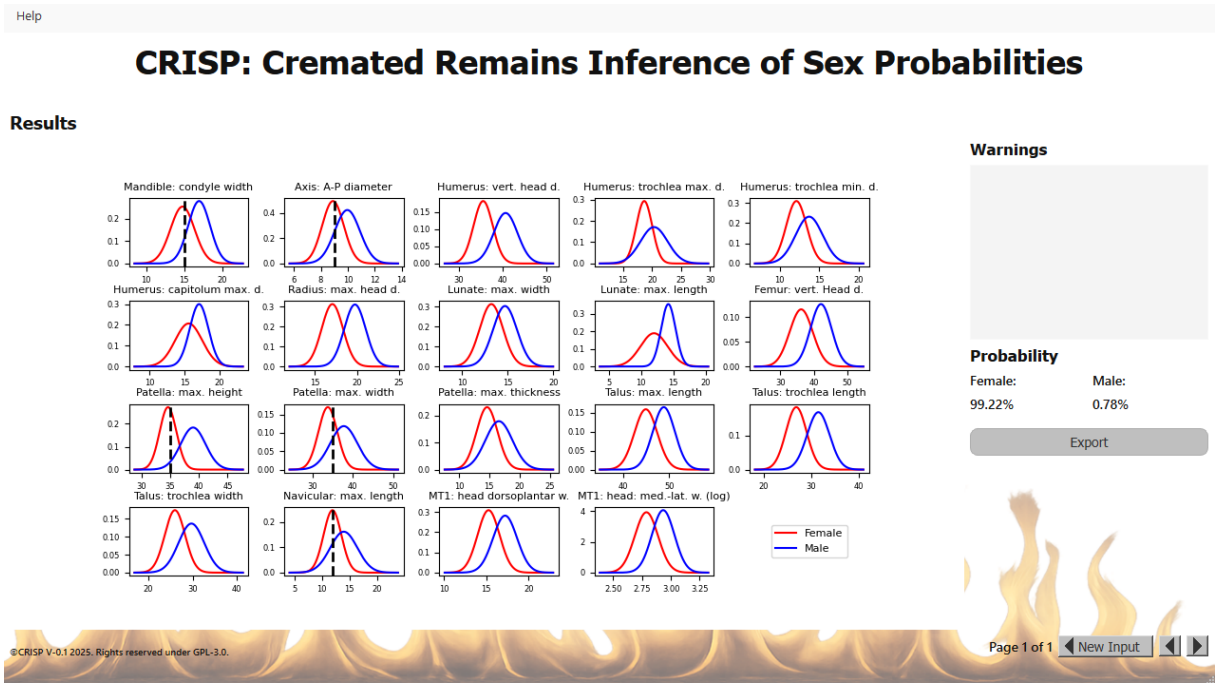


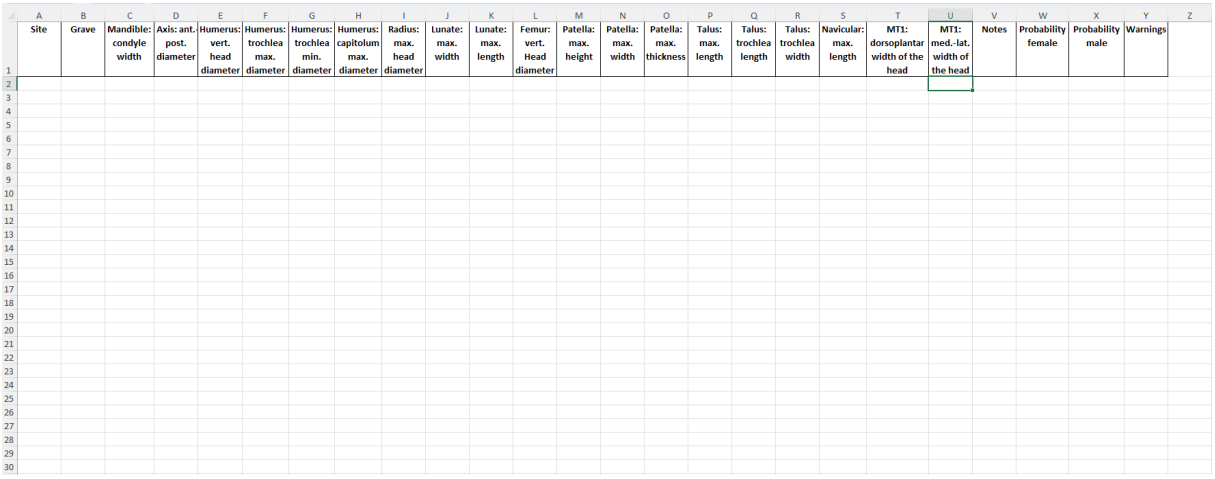
Fig. 3: Results page. The plots represent the data distribution (separated in females and males) used for the prediction model. The vertical dotted lines denote the individual measurements incorporated into the prediction. Right, you can find a box showing warnings, should they occur (see section “Warnings” for more details). Additionally, the results of the sex prediction are presented as probabilities, indicating whether the subject is male or female. The export of a report on the results for individual prediction is initiated by pressing the *Export* button.

The results of the study can be downloaded by clicking the *Export* button. The generation of a PDF file is initiated, which subsequently becomes available for download. In order to proceed, a window will appear, and the user will be prompted to enter the site, grave, number and individual number. These elements will be incorporated into the report as a heading and the document’s title. Consequently, this information is essential, and the PDF cannot be exported without first completing these boxes. Furthermore, there is an additional box in which supplementary notes can be entered. In this section, additional information regarding the grave context (e.g., grave goods) and anthropological analysis (e.g., further results such as age at death estimation, pathological lesions, etc.) on the individual can be entered. This information will be included in the report. We recommend including information on the expression of morphological features available for sex estimation along with the final conclusion on the sex estimation. This information will not be incorporated into the sex prediction model. Following the incorporation of all pertinent information, the report can be stored on the designated computer or at the specified location. The report is entitled "Site_gravenumber_individualnumber.pdf. The PDF will contain information regarding the probabilities of the sex estimation, as well as the density plots.

In the event that the calculation of sex is performed for multiple cases using the Case-by-Case Input, the results for each case are made available on an individual results page. You can switch between the results pages by pressing ◀ or ▶. Please note that the results will only be temporarily saved in the application and will be automatically deleted by closing the software. In order to maintain a record of the results, it is necessary to export them. You can navigate to the main page by pressing New Input in the lower right corner of the page.

Multiple inputs

If several cases are recorded, CRISP offers the capability to estimate the sex of all cases simultaneously. To that end, the template for data recording (Fig. 4) is to be utilized. The Excel spreadsheet can be downloaded by selecting the *Template* button on the data recording page. It is possible to rename the file. Please do not modify any variable names in the first row as this will cause errors during the sex estimation process. The final three columns are designated for the sex estimation outcome, which will be recorded by CRISP (Probability female, Probability male, Warnings). Warnings regarding the sex estimation of single cases will be printed in the last column (Please refer to the section "Warnings" for more details). If you want to exchange the spreadsheet with another data sheet, you can use the *Browse* button again to upload a different file to CRISP. This will also be highlighted in the processing box on the right side of the data recording page. The data recording page contains a section on the right side that displays all completed tasks, including any warnings that may be issued. This feature assists in troubleshooting any issues that may arise.



Site	Grave	Mandible: condyle width	Axis: ant.-post. diameter	Humerus: vert. head diameter	Humerus: trochlea max. diameter	Humerus: trochlea min. diameter	Humerus: capitolum max. diameter	Radius: max. head diameter	Lunate: max. width	Lunate: max. length	Femur: vert. Head diameter	Patella: max. height	Patella: max. width	Patella: max. thickness	Talus: max. length	Talus: trochlea length	Talus: trochlea width	Navicular: max. length	MT1: dorsoplantar width of the head	MT1: med.-lat. width of the head	Notes	Probability female	Probability male	Warnings

Fig. 4: Excel template which can be downloaded by pressing the button *Template*. This file allows to record measurements for multiple cases at once. This file can be uploaded into CRISP, where the sex predictions will be automatically entered.

Warnings

Warnings are generated when individual measurements of an unknown case fall outside the typical value range observed in the data composition. Warnings do not hinter the probabilistic sex estimation but are indications for measurement errors or suspected multiple individuals. We advise the osteologist in charge to critically analyze the cremation burial a second time to conclude whether to keep all measurements for prediction or to reject single measurements due to a suspected second individual or wrong recording. However, bone morphology varies between populations but also within populations, and the described warnings are only a indication but no evidence for multiple individuals.

Warning: variable outside of 3 SDs
This usually refers to values that are more than ±3 standard deviations off the mean of the respective variable and may indicate a wrong measurement.

e.g., *Warning: Mandible: condyle width outside of 3 SDs*

Warning: Inconsistency for few features
This warning will be shown if two to four measurements are included into the sex prediction and the posterior-probabilities for one or two features deviate from each other by more than 0.33 (Δ = maximal difference the single posterior probabilities of two features), single posterior = single posterior probabilities being a male per measurement.

e.g., *Inconsistency for few features! (Δ = 0.980)*
→ single posterior (m):
Mandible: condyle width.m: 0.9882
Axis: ant.-post. diameter.m: 0.0710
Humerus: vert. head diameter.m: 0.0087

Warning: Inconsistency for ≥5 used features
This warning will be shown if five or more measurements are included into the sex prediction and the single posterior-probabilities of variables deviate by more than 0.25 from the median posterior probability (being a male). The variables are sorted ascending based on their single probabilities. Single probabilities which deviate by more than 0.33 from the median posterior probability will be marked with an asterix (*).

e.g., *Inconsistency for ≥5 used features!*
→ Median Posterior(m): 0.32
→ deviation > 0.25 detected:
→ all individual posterior(m) values (ascending):
Axis: ant.-post. diameter.m : 0.075
Humerus: vert. head diameter.m : 0.088
Humerus: trochlea min. diameter.m : 0.323
Humerus: trochlea max. diameter.m : 0.482
*Mandible: condyle width.m : 0.988 **
** = deviation > 0.25*

Warning: non-numeric data input will be ignored.
The data format of the variables only allows metric information for the sex estimation. In case non-numeric information such as letters or special characters are included instead of length measurements, CRISP automatically ignores this data input for the sex estimation. To highlight possible typos, the software provides a warning that the data contained non-numeric recordings.

e.g., *Warning: non-numeric data input will be ignored.*

FAQ

Q: I got nan% for the probabilities as a result, including a warning that a measurement is outside of three standard deviations.

A: If measurements are included which are more than 10 standard deviations of the mean, the sex estimation may fail by showing unreliable probabilities or showing nan%. Please check your measurements.

Q: On or more cases in the Excel spreadsheet do not show probabilities for sex estimation after calculation but, including a warning that a measurement is outside of three standard deviations.

A: If measurements are included which are more than 10 standard deviations of the mean, the sex estimation may fail by showing unreliable probabilities or showing nan%. Please check your measurements.

Q: I want to calculate multiple cases, but I receive the error message "Error: File has been opened, moved or deleted since selection.

A: CRISP primarily saves the path to file in the first step (button *Browse..*). If you removed or renamed the file after selecting the path, CRISP cannot find it anymore. Please re-select the correct path via *Browse.. .* In the event that the Excel file is being opened on one's computer in the background, CRISP is unable to save the results into the aforementioned file. Please close it prior the calculation of the sex prediction.

Q: Why do I need to include a sitename, grave number and individual before downloading the report? I do not want to enter a site name.

A: CRISP employs this information as a heading in the report. Of particular significance is the utilization of this information in the designation of the PDF file. In the absence of a designated site name, users are permitted to assign any desired name to the PDF file.

Troubleshooting

Check process field for errors.

Support contact details

For further questions and/or reporting bugs and errors, please contact crisp.support@gmail.com.