
iDaVIE-v
Release 1.0-beta.0

IDIA Vislab, INAF-OACT

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IDAIE-V USER MANUAL

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INTRODUCTION

Note: The current version of the software is in beta testing so please be aware that issues might arise. We also appreciate your collaboration in identifying them and, if you do, please post them in the issues page on [Github](#). All issues will be fixed for the first data release.

1.1 The mission of iDaVIE-v

iDaVIE-v is part of the iDaVIE software suite which is under development at [IDIA](#). The DaVIE-v application has been developed in collaboration with [INAF-OACT](#). The specific goal of iDaVIE-v is to enable the interrogation of data cubes using Virtual Reality Technology. For more details about the iDaVIE software suite development and all its aspects please refer to [Jarrett et al. 2021 \(in press.\)](#).

1.2 Codebase and releases

iDaVIE-v is an open-source project. Its source code will be made available after the Beta testing is concluded.

Installation guides are provided in the section *Installation and configuration*, including the installation of the needed VR environment.

The release plan and major goals are the following:

- v1.0-Beta.0: complete software only in executable format (released on 18th March 2021)
- v1.0-Beta.1: fixed deployment DLL bug (released on 29th March 2021)
- v1.0-Beta.2: fixed loading frequency-based cubes issue (released on 10th April 2021)
- v1.0-Beta.3: added ability to load and interact with large catalogue (released on 7th July 2021)
- v1.0-Beta.5: added ability to export sub-cubes and edit settings using a JSON config file (released on 8th October 2021)
- v1.0-Beta.6: added ability to load new cubes without exiting iDaVIE; Updated file browser to use system-default browser; added toaster notifications for information, warnings and errors (released 18th February 2022)
- v1.0-Beta.7: fixed memory leak, fixed behaviour of edited masks when viewing downsampled cubes, added ability to paint small cubes without cropping (released 20 July 2022)
- v1.0-Beta.8: added physical units to V_{sys} and W_{20} calculations, added colorbar to moment maps, fixed cube shape bug in desktop GUI, removed colormap toast notifications (released 10 January 2023)

- **v1.0-Beta.9 (current release)**: upgraded Unity version to latest LTS 2021, upgraded SteamVR plug-in to latest 2.7.3 (released 2 February 2023)
- v1.0: complete software and source code (release date TBC)

1.3 Getting help

The iDaVIE team welcomes any suggestion, feature request, or bug report, to make iDaVIE-v better via

- Recommended: [Github Issue](#)
- Only if necessary: [IDIA vislab help \(vislab@idia.ac.za\)](mailto:vislab@idia.ac.za)

1.4 Contributors

The development of the iDaVIE-v project is a joint effort from:

- [The Inter-university Institute for Data Intensive Astronomy \(IDIA\)](#)
- [The IDIA Visualisation Lab](#)
- [Osservatorio Astronomico di Catania, Istituto Nazionale di Astrofisica \(INAF-OACT\)](#)
- [Osservatorio Astronomico di Cagliari, Istituto Nazionale di Astrofisica \(INAF-OACA\)](#)

1.5 Software citation

Please use the following DOI as a citation when using iDavie-v for publications.

Other relevant references are:

- “Exploring and Interrogating Astrophysical Data in Virtual Reality”, [Jarrett et al. 2021 \(in press.\)](#)
- “iDaVIE-v: immersive Data Visualisation Interactive Explorer for volumetric rendering”, [Marchetti et al. 2021 \(in press.\)](#)
- “Virtual Reality and Immersive Collaborative Environments: the New Frontier for Big Data Visualisation”, [Sivitilli et al. 2021 \(in press.\)](#)

1.6 Acknowledgements

- The Inter-University Institute for Data Intensive Astronomy is a partnership of the University of Cape Town, the University of Pretoria and the University of the Western Cape.
- This project received support from the National Research Foundation under the Research Career Advancement and South African Research Chair Initiative programs (SARChI)
- This project received support from the Italian Ministry of Foreign Affairs and International Cooperation (MAECI Grant Number ZA18GR02) and the South African NRF (Grant Number 113121) as part of the ISARP RA-DIOSKY2020 Joint Research Scheme

iDaVIE-v is mainly built using the Unity game engine and with the following third-party libraries:

- SteamVR
- CFITSIO

1.7 Copyright and License

Copyright (C) 2022 IDIA, INAF-OACT. This program is free software; you can redistribute it and/or modify it under the terms of the [GNU General Public License version 3](#) as published by the Free Software Foundation.

SYSTEM REQUIREMENTS

2.1 Hardware

In order to run the software, a system capable of running SteamVR is required. The system requirements are given on the [SteamVR store page](#). We recommend at least an NVIDIA GTX 1070 or above, or the equivalent AMD GPU.

A quad-core or higher CPU is recommended. At least 8 GB of RAM is required. However, the size of the data cubes usable will depend heavily on system memory capacity. We recommend 16 GB, or 32 GB to support large data cubes.

Any VR headset compatible with SteamVR should function. The following VR headsets have been tested:

- Meta Rift
- Meta Rift S
- Meta Quest 2
- HTC Vive
- HTC Vive Pro
- Valve Index
- Samsung Odyssey

Tip: In the IDIA Visualisation Lab we use the Valve Index (with wall-mounted sensors), while on the road we use Alienware gpu-powered laptops and the Meta Rift S.

2.2 Software

In order to run iDaVIE-v the following software needs to be installed:

1. Windows 10 (version 1903 or newer) is required.
2. The SteamVR runtime is required. Note that in order to start SteamVR, some headsets (e.g. Meta headsets) require additional software to be installed. Instruction should be provided on the headsets webpage.
3. The latest 64-bit (X64) [Visual C++ redistributable](#) needs to be installed.

INSTALLATION AND CONFIGURATION

Note: The current version of the software is in beta testing so please be aware that issues might arise. We also appreciate your collaboration in identifying them and, if you do, please post them in the issue page on [Github](#). All issues will be fixed for the first data release.

3.1 Executable

Once the requirements described in *System requirements*, are installed and working correctly, the user can download and unzip the provided `iDAVIE-v_v.0-beta.8.zip`, which contains the executable `.exe` (and other reference files). The zip file is available on Github at this [link](#).

To start the software, double-click on the executable `iDaVIE-v` file.

3.2 Source code

Currently not available. The source code will be made available after beta is completed.

3.3 Troubleshooting

In this section we share some useful tips where we found a solution to a known issue:

- Under some circumstances the voice commands stop to work. If this happens we found that the following sequence of actions solves the problem (**NOTE:** this solution has been tested only with Oculus Rift S and on machines where the RealTek Audio driver is installed, we cannot assure it will work for any set up)
 1. take the headset off
 2. make sure the `iDaVIE-v` Desktop GUI is front and center and no other windows are in front of it
 3. use the Windows search function (lower left hand corner - says Type here to search), and type audio
 4. open the RealTek Audio Console that will appear after the search
 5. check that the Microphone is set to maximum; toggle <mute> on and then off. Now the mic should be on and ready to receive commands.
 6. close the Audio Console
 7. put the headset back on and use the voice commands as normal.

- If errors are encountered that you can't solve, please:
 1. post and issue on the Github repository
 2. make contact with us and send us the log files along with your bug reports. The log files can be found in the directory %appdata%/./LocalLow/IDIA/iDaVIE-v. In order to find this directory using Windows please press WIN + R to open the run dialog, and paste the path directory in to open the folder).

Warning: Unity only allows for a maximum of two log files to be stored. Therefore, if a problem is encountered with iDaVIE-v is best to copy the log file to a different folder **BEFORE** starting a new iDaVIE-v session otherwise the log file reporting the specific problem encountered will be lost.

3.4 Known issues

The following are issues we already know about and that will be fixed as soon as possible:

1. In order to paint, a region must be selected and cropped to
2. Problem with virus protection systems. We will make a request to Norton to have our software “whitelisted”. In the meantime the virus protection does not recognize the .exe and puts up the warning. See more details [here](#)
3. A DLL deployment bug has been found in v1.0-beta.0 and has been fixed in v1.0-beta.1 and later versions. We refer the user to the latest version to solve this issue.
4. Issues loading frequency-based cubes have been fixed in v1.0-beta.2 and later versions.

INPUT & OUTPUTS

In this section we describe what kind of file format can be ingested in iDaVIE-v and what file and in which formats are saved as data product of iDaVIE-v.

4.1 Inputs

Standard Real*4 (32-bit) FITS cubes for both the data and the (optional) mask. There should be three axis, as defined by NAXIS1, NAXIS2 and NAXIS3 in the header. Avoid using the NAXIS4 as the third dimension, it is ignored by the software. Multiple catalogs can also be loaded if in VOTable format.

4.2 Outputs

iDaVIE-v provides:

- **PNG** files of screenshots and moment maps stored in `Output/Camera`
- **VOTable** catalog originated by an edited or created mask stored in `Output/Catalogs`
- **FITS** file of created/modified mask:
 - if a mask is loaded and modified in VR then it can be saved either overwriting the original mask **or** as a copy. In the former case the mask will be saved with the same name of the original mask and in the same directory, in the latter case the suffix `-copy.fits` will be added to the original mask name and the edited mask will be saved in the same directory as the original mask (e.g. the edited mask file name will then be `originalmaskname-copy.fits`).
 - if no mask is provided in input, but one is created in iDaVIE-v, then the created mask is saved in the same directory of the data cube and a suffix `-mask.fits` will be added to the cube name to indicate the mask file (e.g. the created mask file name will then be `originalcubename-mask.fits`).

GRAPHICAL USER INTERFACE

Note: This section is under construction. We apologies for the inconvenience.

iDaVIE-v presents two tyoes of GUI: the **Desktop GUI** which is the one the user will interact with while at the computer/desktop using the keybord and the **VR GUI** which is the one the user will interact with in the VR environment using the VR controllers.

5.1 Desktop GUI

This is the GUI that the user use to start the VR session. It is the first thing that appear to the user on the computer screen when iDaVIE-v.exe is executed.

Using this GUI the user can load the “data cube” of its choice pressing the “Browse” button on the “Image File” line.

NOTE: Users can also loads cube that have 4 dimensions. If a cube with four dimensions is loaded the system will give the opportunity to choose which axis (3 or 4) to use based on the header of the cube. To choose the Z axis a drop down menu will appear for the z axis selection.

Once the cube is loaded the user can do one or more of the following actions:

1. Check the header of the cube reported in the grey rectangle (in order to check whether the software has interpreted it correctly).
2. Tune the rendering of the cube using the options in the RENDERING tab or check some basics stats of the cube (these can also be done using the Main Menu options in the VR GUI)
3. Load a mask file (if any) by pressing the “Browse” button on the “Mask File” line. **NOTE:** the mask must have the same dimensions of the cube loaded. See below, both the FITS cube and the mask have been selected. Now you are ready to Load and render.
4. Load a catalog of sources (if any) using the “SOURCES” tab. In this case the user will need to indicate which columns needs to be imported and which columns are ID, Right ascension, Declination and redshifts. These latter are essential columns to proceed with the 3D rendering of the catalog.
5. Skip all the previous step and just press “Load”. Once this is done the user can wear the headset and start exploring the cube. The first look the user will see is something like this:

Axes are RGB color coded as:

Red, Green = X, Y (e.g. RA, DEC respectively)

Blue = Z (e.g velocity, redshift)

5.2 VR GUI

TBD

5.2.1 Main menu

TBD

5.2.2 Quick menu

TBD

5.2.3 Mask painting menu

TBD

5.2.4 Saving menu

TBD

5.2.5 Stats & Moment maps menu

TBD

HOW TO INTERACT WITH THE DATA IN VR

6.1 Sitting or standing?

If you are new to VR when you start using iDaVIE-v we share here some tips on how to get comfortable while using VR:

1. **You don't have to stand.** For long use we suggest you sit while ensuring there is enough room to freely move the controllers without crushing
2. **You can walk around the data or move the data towards/around you** while comfortably sitting.
3. We developed the software with care to avoid risks related to motion sickness so we don't expect problems with this. Nevertheless, if you never use VR before we suggest you start by moving slowly in the VR environment in order to get use to the new perspective.

6.2 How to use the controllers

In this section we provide guidelines on how to use the Oculus controllers as this is our testing scenario. We can provide guidelines upon request on how to use e.g. VIVE controllers instead.

Tip: When setting up the VR system you can choose which hand is your “primary hand” you will use to deliver commands. This can also be set using the iDaVIE-v Main Menu in the VR GUI. Usually right-handed people will set the right hand to be the primary hand and the left hand to be the secondary hand. The viceversa usually applies to left-handed people. In the following we will describe both scenarios and will refer to primary hand and secondary hands in this sense.

1. **Thumbstick (primary hand):** it can be used to scroll (up and down) lists (aka catalogs)
2. **Thumbstick (secondary hand):** it can be used to undo/redo a painting action (when in paint mode) by moving left (to undo) and right (to redo after undoing).
3. **Menu button:** this should NOT be pressed, it is a Oculus function unrelated to our software
4. **Grip button:** For navigation. Hold button down with one hand, this ‘grabs’ the cube, and you can move it around with hand/arm motion; press grip button on both hands to zoom in and out (arm motion in/out along horizontal axis), and rotation (hand/arm motion that is a scissor motion).
5. **“Y” or “B” button:** it activates the quick menu option (see *Graphical User Interface*). If the primary hand is set to be the left hand then the reference button is the “Y” button; if the primary hand is set to be the right hand then the reference button is the “B” button.

6. **“X” or “A” button:** it activates the selection option. Use this to create a box around a region (e.g. a source) of choice. How to use this: you reach your hand behind and upward of the object (in 3D), press and hold button as you drag it across and down the source, creating a box within which your region of interest should be. After you have selected the source, you can crop the box using either a voice command “Crop Selection” or the Crop button in the Quick Menu. If the primary hand is set to be the left hand then the reference button is the “X” button; if the primary hand is set to be the right hand then the reference button is the “A” button.
7. **Trigger:** it is used for a number of actions:
 - once a menu is active a laser pointer will be visible. The trigger can then be used to select options on menus.
 - when the voice command “Edit min” or “Edit max” or “edit z* axis” (see section Voice commands) are activated, the user can change the min/max thresholds or tune the z-axis, by moving up/down or right/left the primary hand respectively. In both cases, when the user is happy with the new threshold or z-axis can use the trigger to save the new configuration.

6.3 Voice commands

In VR the use of the controllers can become tricky so we have implemented a series of voice commands that can be used as an alternative to interact with the data. The list below contains all the possible voice commands that can be used in alternative to the options in the VR quick menu. Each of the following commands will have the exact same outcome as the menu actions. A vocal command is activated once the user receive an haptic feedback (vibration) on the main hand controller. If no feedback is received than the voice command did not activate and the user should try again.

Command	Description
Changing voxel thresholds	
“Edit min”	to set the minimum threshold (floor) of the voxel intensity mapping
“Edit max”	to set the maximum threshold (ceiling) of the voxel intensity mapping
“Reset threshold”	to reset the thresholding to the default (startup) values
Changing color map	
“color map plasma”	to set the color map to a favourite one. Options are: plasma, turbo, rainbow, magma, inferno, viridi, cube helix
“reset transform”	to reset the color mapping to the default magma color map
Changing ray marching settings	
“projection maximum”	(DEFAULT) ray-marching with maximum voxel intensity
“projection average”	ray-marching with average along line-of-sight
Changing voxels scale	
“linear scale”	(DEFAULT) voxel values are displayed in linear scale
“log scale”	voxel values are displayed in log scale
“square root scale”	voxel values are displayed in square root scale
Changing cube size scaling	
“edit zee axis” or “edit zed Axis”	to edit the z-axis of the cube (e.g. to compress the cube to a single layer or stretch it). NOTE: by doing this action no beam convolution is taken into account. We assume that every channel has the same beam size. Only in the Beta release there will be the opportunity to create a moment-0 map of the cube and thus a proper convolution will be done (if different channels have different beams).
“save zee axis” or “save zed Axis”	to save the new z axis scale
“reset zee Axis” or “reset zed Axis”	to reset the z-axis to the default (startup) values

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Command	Description
Selecting regions of interest	
“crop selection”	after selecting an object/region of interest using the controllers this command will crop the region within the box from the full cube and will render it at full resolution (depending on the dimension of the selected region)
“reset crop”	to return to the full cube view
Visualisation of cube masks	
“mask on”	if a cube mask is loaded this command will allow to visualise only those voxels that belong to the mask
“mask off”	to turn off the mask visualisation
“mask invert”	opposite of mask on; to show anything that is not in a mask or, in other words, to show the “residuals” (cube - mask cube); usefull to find new sources
“mask isolate”	to light up the masked voxels; use to easily see mask
Painting options	
“paint mode”	to activate the paint mode where the user can modify/create a mask
“exit paint mode”	to exit the paint mode
“brush add”	to add voxels to a mask
“brush erase”	to delete voxels of a mask
“show mask outline”	to show the mask outline as a transparent grid (DEFAULT: the mask outline will be authomatically set when in paint mode)
“hide mask outline”	to hide the mask outline as a transparent grid
“undo”	undo a paint mode action
“redo”	redo a paint mode action
“add new source”	to specify the user is now adding a new source to the mask
“set source ID”	to set the mask voxels the user is about to paint to the value of a specific source ID. In this way the software will recognize the voxels as part of a specific source indicated and not as a new source.
Screenshot options	
“take picture”	to take a screenshot of what is in front of the user in VR. The screenshot taken will then be authomatically saved as a .png file in ??????
Catalog actions	
“teleport”	when a source is selected in a list this command will teleport the user at the position of the source in the cube
Get cursor information	
“cursor info”	to visualise any info available for the voxel where the cursor is. Default information are WCS,v_rad, volume value, voxel value in the Units of the cube, Frequency (if stored in the header), source ID (if a mask is loaded).

Note: We are aware that the voice commands do not work when the user is recording a movie using an external software. In this case the user should use the menu options. See more in the section *“How to” demos*.

“HOW TO” DEMOS

Note: This section is under construction. Some elements in the videos may slightly differ from what the user actually see in the rendering of the current software. We apologies for the inconvenience.

In this section we store example videos that should intuitively explain how to use iDaVIE-v.

7.1 Explore a cube

Exploiting the controllers described in *How to interact with the data in VR* the user can zoom in on the data and move the data where needed using the grip buttons. Then with the A button (if the primary hand is the right) or the X button (if the primary hand is the left) the user can select a region around a point of interest. The user can then use the voice command “Crop selection” to crop the cube to the region selected.

The 3D cursor will provide infos on the voxel where is located, if a mask is loaded then the cursor info will also provides feedbacks on the identified sources like in this case:

7.2 Take snapshots

iDaVIE-v allows to take a “screenshot” of what is in front of the user in a particular moment. To do so the user can do any of the followings:

1. invoke the quick menu and laser on the camera icon and press the trigger (of the primary hand) while paying attention to look in the direction of what is meant to be captured in the picture (e.g. if the user looks to the menu when pressing the trigger than the picture will contain only the menu)
2. while looking to what needs to be captured the user can say “take picture”. To prove that the picture has been taken and stored the user will receive an haptic feedback (vibration) on the primary hand controller.

7.3 Create/modify/save a mask

iDaVIE-v allows to create a mask or to modify an existing mask in VR. Both can be done using the “Paint menu” that can be invoked from the “Quick menu” by lasering the brush icon. Using the functionality available in the “Paint menu” the user can add or delete mask voxels using the controllers. Once done the user can save the created/updated mask overwriting an existing one or creating a new one. As also explained in *Input & Outputs*:

- if a mask is loaded and modified in VR then it can be saved either overwriting the original mask **or** as a copy. In the former case the mask will be saved with the same name of the original mask and in the same directory, in the

latter case the suffix `-copy.fits` will be added to the original mask name and the edited mask will be saved in the same directory as the original mask (e.g. the edited mask file name will then be `originalmaskname-copy.fits`).

- if no mask is provided in input, but one is created in iDaVIE-v, then the created mask is saved in the same directory of the data cube and a suffix `-mask.fits` will be added to the cube name to indicate the mask file (e.g. the created mask file name will then be `originalcubename-mask.fits`).

Demo TBD

7.4 Interact with catalogs in VR

iDaVIE-v allows to load catalogs from the Desktop GUI and to overplot them on the visualised data cube.

7.5 Create stats and save moment maps

iDaVIE-v allows to investigate basic stats of the cube and to create both moment 0 and moment 1 of a data cube. The user can create the moment maps for the entire cube or for a single selected region. In case a mask is available the moment maps thresholds are set by the mask, but they can be changed manually. If no mask is available then the thresholds should be set manually using the options available in the moment map windows. The moment maps can then be saved as png.

7.6 Create a movie (using external tools)

TBD

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