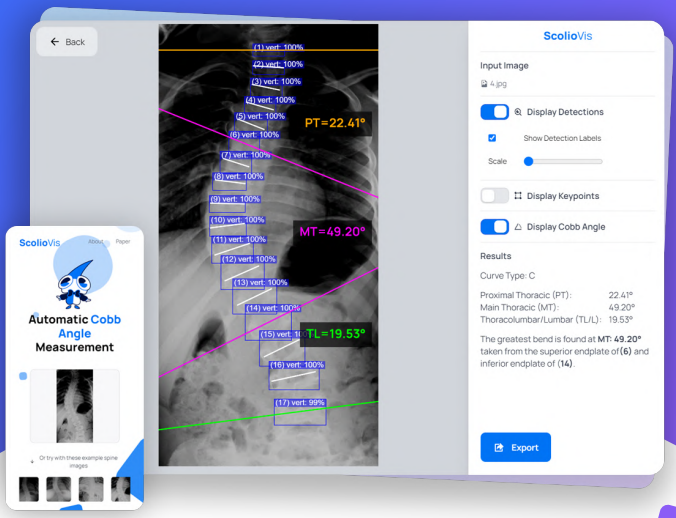
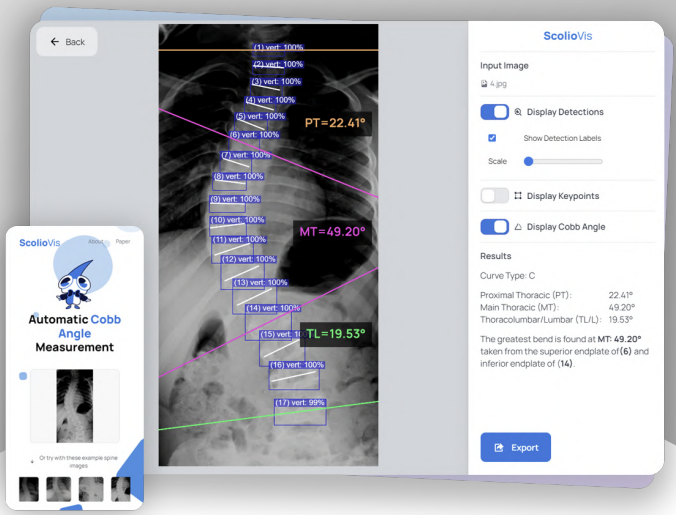


ScolioVis

Automated Cobb Angle Measurement on Anterior-Posterior Spine X-Rays using Multi-Instance Keypoint Detection with Keypoint RCNN

User Manual

WVSU-CICT Research by
Taleon, Elizalde, Rubinos (BSCS-4A)



ScolioVis is an innovative tool that helps medical professionals accurately measure the Cobb angle on anterior-posterior spine X-rays, a crucial step in the diagnosis and treatment of Scoliosis. Developed by a team of 4th year Computer Science students from West Visayas State University, *ScolioVis* leverages state-of-the-art computer vision and machine learning technologies to achieve impressive levels of accuracy in Cobb angle measurement. With its intuitive interface and seamless integration with other healthcare systems, *ScolioVis* is designed to make the process of diagnosing and treating Scoliosis faster and more efficient.

If you're a medical professional looking to improve your workflow and provide more accurate diagnoses and treatments for your patients, *ScolioVis* is the solution you've been waiting for.

ScolioVis

Automated Cobb Angle Measurement on Anterior-Posterior Spine X-Rays using Multi-Instance Keypoint Detection with Keypoint RCNN

An Undergraduate Thesis
Presented to the Faculty of the
College of Information and Communications Technology
West Visayas State University
La Paz, Iloilo City

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science in Computer Science

by
Carlo Antonio T. Taleon
Glecy S. Elizalde
Christopher Joseph T. Rubinos

March 2023

Disclaimer

This software project and its corresponding documentation entitled ***"ScolioVis: Automated Cobb Angle Measurement on Anterior-Posterior Spine X-Rays using Multi-Instance Keypoint Detection with Keypoint RCNN"*** is submitted to the College of Information and Communications Technology, West Visayas State University, in partial fulfillment of the requirements for the degree, Bachelor of Science in Computer Science. It is the product of our own work, except for the utilization of the Spine Web Dataset 16: 609 spinal anterior-posterior x-ray images. Any publication resulting from any use of this database must cite the following paper:

> *Wu, H., Bailey, Chris., Rasoulinejad, Parham., and Li, S., 2017.Automatic landmark estimation for adolescent idiopathic scoliosis assessment using boostnet. Medical Image Computing and Computer Assisted Intervention:127-135.*

This project is intended for academic and research purposes only and is not intended to be used for clinical or diagnostic purposes. The accuracy of the results produced by the ScolioVis system has not yet been fully validated and should not be relied upon for medical decision making.
We hereby grant the College of Information and Communications Technology permission to freely use, publish in local or international journal/conferences, reproduce, or distribute publicly the paper and electronic copies of this software project and its corresponding documentation in whole or in part, provided that we are acknowledged.
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No License

ScolioVis has no open-source license, hence we explicity state that this project, including the subrepositories: scoliovis-web, scoliovis-api, scoliovis-training are under exclusive copyright of the authors and the College of Information and Communications Technology, West Visayas State University by default. The source code is only publicly available for documentation purposes.

Table of Contents

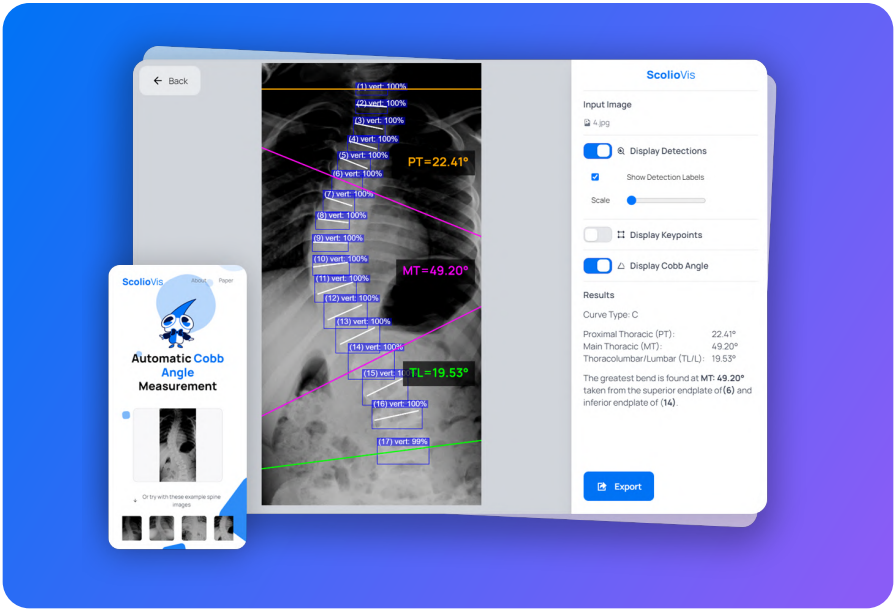
Getting Started

Introduction

ScolioVis is a tool for automatically measuring the Cobb Angle—the standard measurement to assess Scoliosis. We harness the power of computer vision and machine learning to extract the cobb angles of an anterior-posterior Spine x-ray image. We built this application from the ground-up to an actual implementation in a usable web app.

This user manual does and does not help you with the following:

- ✅ How to host/install the web app on your local machine.
- ✅ How to use the app's main features.
- 🚫 How to train our model



A live demo is available on

https://scoliovis.app/

System Requirements

	Frontend	Backend
Operating System	Any OS that supports Node.js	Any OS that supports Python
CPU	0.1 vCPU or 100 milicores; Recommended: 1 vCPU	0.3 vCPU or 300 milicores; Recommended: 1 vCPU
GPU	None	None; Recommended: CUDA-enabled GPU
Disk and Memory	850MB of free disk. At least 512MB RAM.	3 GB of free disk. At least 1GB RAM.
Internet	Internet connection required for installing dependencies	

Interested in Training the Model from scratch?

Follow the instructions on
https://github.com/blankeos/scoliovis-training

Installation

> This following section will teach you how to host/install the web app on your local machine. If you're only interested in using the app's main features, you can skip this section.

Before proceeding, install the following requirements on your machine:

- Git
- Node.js® v18.12.1 or higher
- PNPM `npm install --global pnpm`
- Python 3.9.6 or higher

1. Installation: Frontend

Open a CLI anywhere you want to install the package and perform the following commands:

```
# 1. Clone package repo
D:> git clone https://github.com/blankeos/
    scoliovis.git
D:> cd scoliovis\src\frontend

# 2. Install dependencies
D:\scoliovis\src\frontend> pnpm install

# 3. Run the server on http://localhost:3000
D:\scoliovis\src\frontend> pnpm build
D:\scoliovis\src\frontend> pnpm start
```

2. Installation: Backend

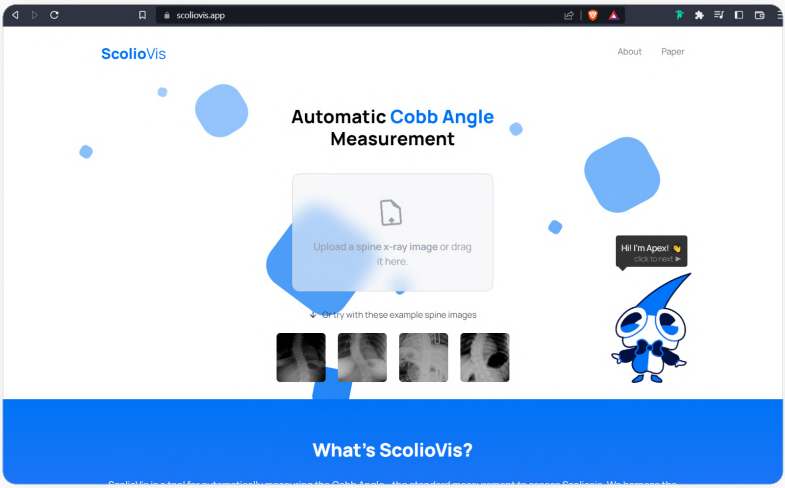
While the frontend is running, open another CLI in the same directory and perform the following commands to go to the backend:

```
# 1. Go to the backend directory
D:\scoliovis\src\frontend> cd ..
D:\scoliovis\src> cd backend

# 2. Create a virtual environment
D:\scoliovis\src\backend> python -m venv venv

# 3. Activate virtual environment
# - If you're on Windows Command Prompt
D:\scoliovis\src\backend> venv\Scripts\activate

# - If you're on Mac or Git Bash
D:\scoliovis\src\backend> source venv/Scripts\
                          activate

# 4. Install dependencies
(venv) D:\scoliovis\src\backend> pip install -r
                                 requirements.txt

# 5. Download the keypointsrcnn_weights.pt and
     place inside /models:
      • https://github.com/Blankeos/scoliovis-
        training/releases

# 5. Run the server on http://localhost:8000
(venv) D:\scoliovis-api> uvicorn main:app
```

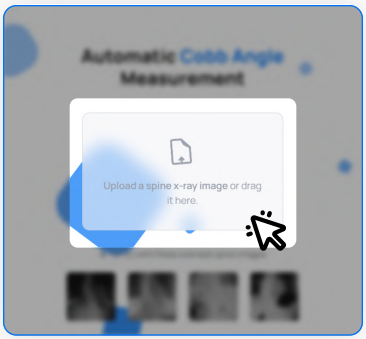
The reason why we download the model separately is because it's **too big** for git!

Usage

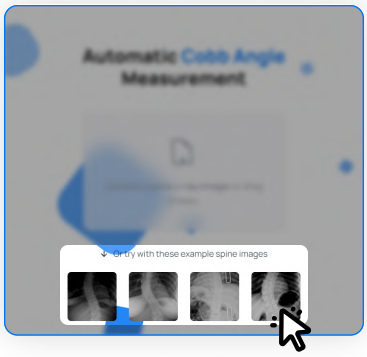
1. **Go to the homepage.**
   The homepage is the main entry-point of our app which can be access via https://scoliovis.app/ on any browser. Upon going there, you will be greeted by **Apex** in the following page:



2. **Select a spine image for analysis.**
   There are two ways to select a spine image for analysis. You can either:



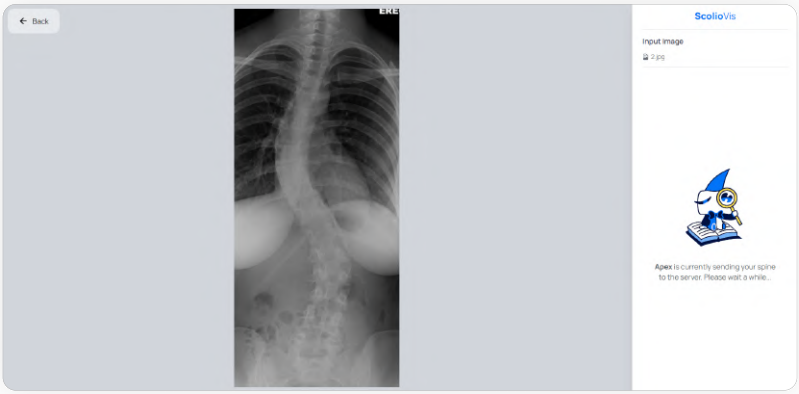
a. Upload a spine image from your local device.



b. Select a provided Spine Image from our dataset.

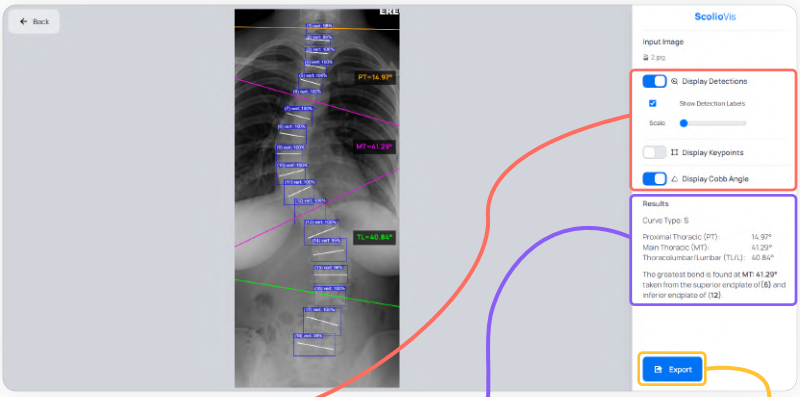
3. Spine image will be sent to the backend server.

After selecting an image, your image will be sent to our server. You can wait for **5-10 seconds** while our AI model is analyzing your image.



4. Get the results!

After the model returns its analysis, your spine image will be rendered with the following results which can help you analyze just how bad your scoliosis is.



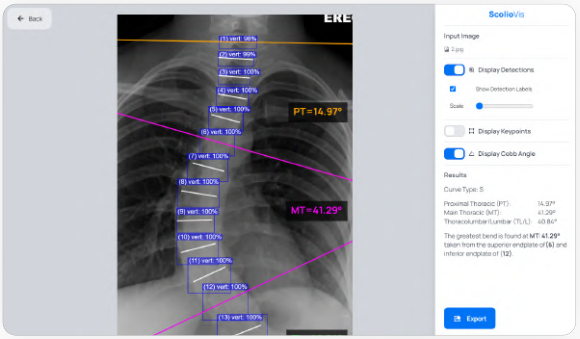
Customize the way the resulting image is rendered.

View angle measurements of every section of the spine.

export results to pdf, png, jpeg, or print!

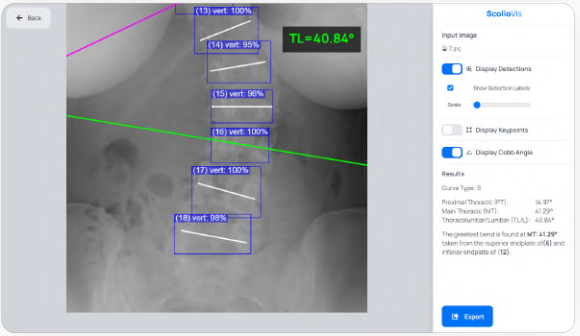
5. Zoom and Pan!

Inspired by apps like Figma, you also have the freedom to zoom and pan on the image to give you a better visualization experience.

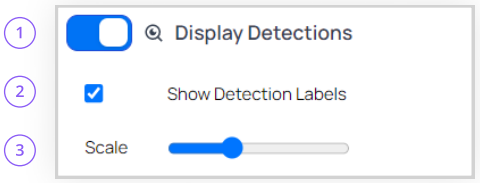


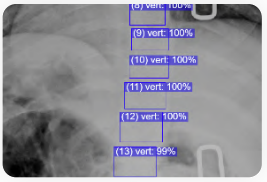
scroll to zoom

Click and drag to pan!



6. Display Detections

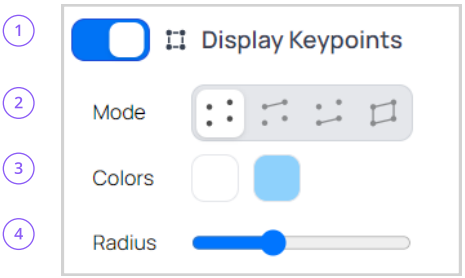


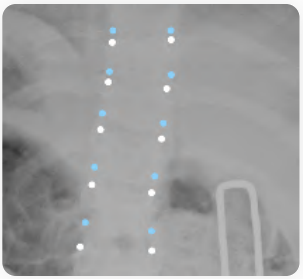


1. Press the display detection switch to show or hide the detection boxes.
2. Hit the check mark button to show or hide the detection labels.
3. Adjust the scale bar to change the border width.

7. Display Keypoints

The display keypoints feature allows you to customize how the keypoints and vertebrae lines are drawn on the canvas.





1. Press the **Display Keypoints Switch** to show the different customization settings for the keypoints.
2. There are four different modes allow you to choose how each vertebrae lines and points should be drawn:

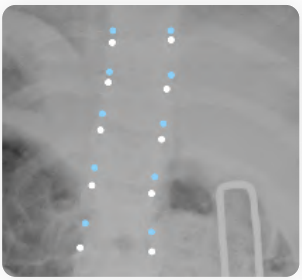
 no lines

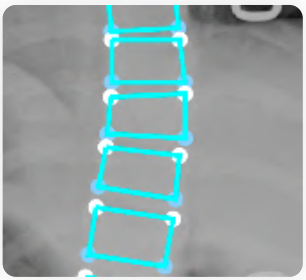
 upper lines only

 no lines

 upper lines only

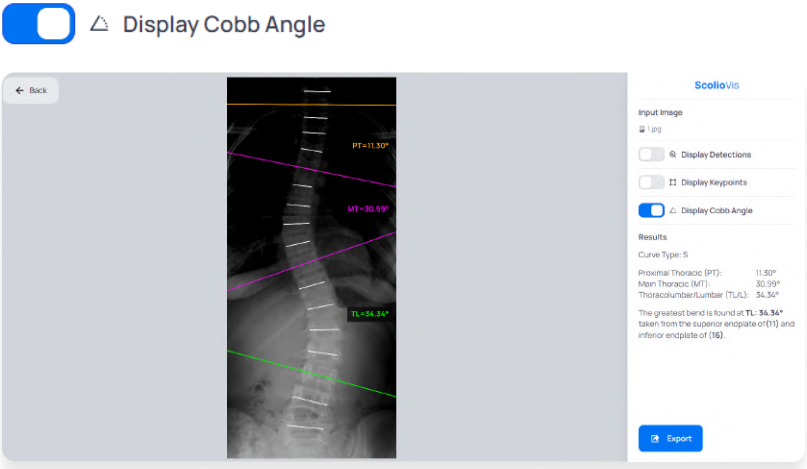
3. In the colors setting, you can choose what color the keypoints and lines are.
4. The radius setting allows you to change the radius of the keypoints.

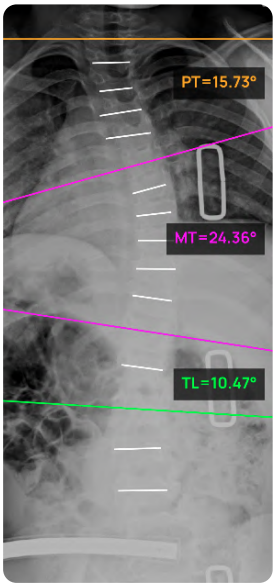




8. Display Cobb Angle

This feature allows you to visualize the different cobb angle measurements found.





PT is Proximal Thoracic

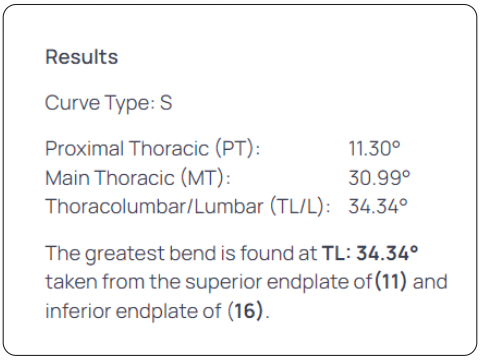
MT is Main Thoracic

TL is Thoracolumbar/Lumbar

9. Results

The results can be found in the lower right corner of the interface.

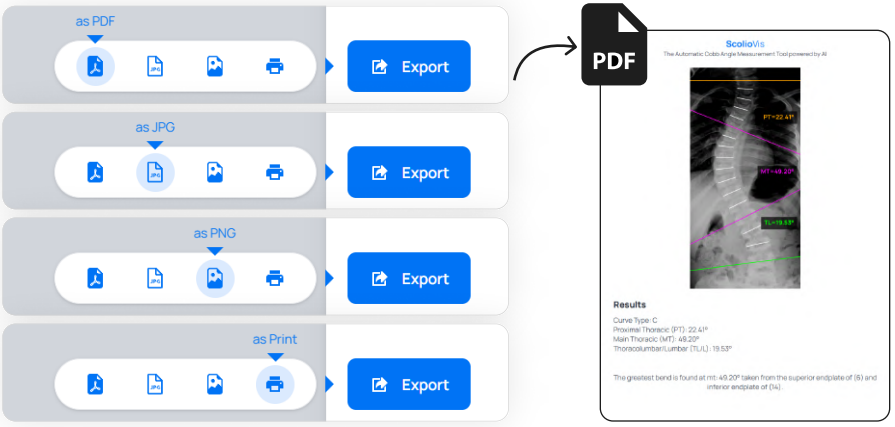
- You're able to see the curve type which either be **S** or **C**.
- The angles of the three different parts of the 17 vertebrae: Proximal Thoracic (PT), Main Thoracic (MT), and Thoracolumbar/Lumbar (TL/L).
- The biggest angle is usually the most important here. ScolioVis also gives a short description about where this biggest Cobb Angle was found.



10. Export

After you are contented with the image, you may choose to print it or export it as PDF, JPG, PNG, or for Print.

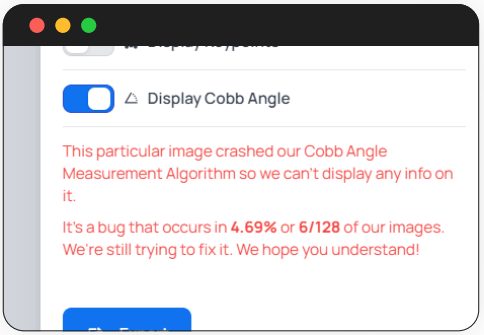
(Note: **JPG** and **PNG** do not export the results details)



Troubleshooting

For any potential bugs, please consider the following courses of action:

E01: Crashed Cobb Angle Measurement Algorithm



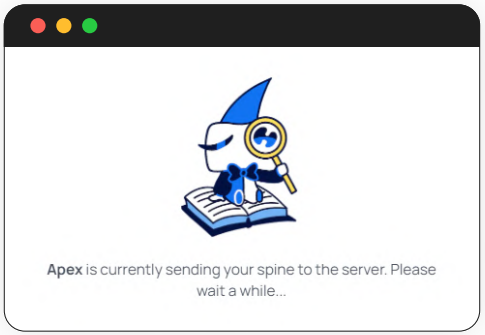
Possible Causes:

- You did not upload an image of an anterior-posterior spine.
- Your image is too large.
- If you uploaded an actual image of a spine and it causes this error, it's a bug that happens **4.69%** of the time.

Solutions:

- Upload an actual image of a spine. ScolioVis does not determine if the image you uploaded is a spine or not, so it tries to find the cobb angle anyway.
- Your image is too large. Try compressing it and uploading again.
- Your particular spine image is one of the **4.69%** anomalies that cause this error in our algorithm. We're working to fix this bug but try a different image for now.

E02: Request taking too long



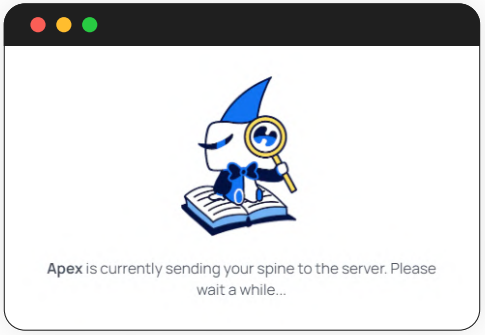
Possible Causes:

- Image is too large.
- Our server is still cold starting after a period of inactivity.

Solutions:

- Your image is too large. Try compressing it and uploading again.

E03: Server did not respond



Possible Causes:

- Our server might not be running to process your request.
- Your image crashed our server.

Solutions:

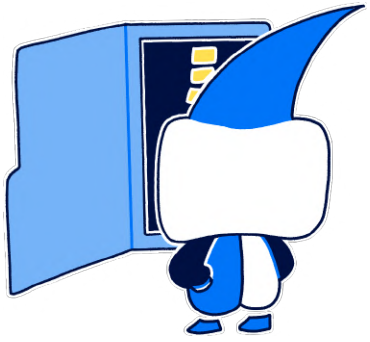
- Contact one of the researchers via our emails in the contact section of this manual.
- Try not to upload an image that is too large, otherwise it will overload and crash the server.

For any other bugs or errors try the following:

- Restart your device or application to see if the issue resolves itself.
- Check your network connection or Wi-Fi settings tro make sure they are configured correctly.
- Try using a different device or browser to see if the problem persists.
- Clear your browser's cache and cookies.
- Check your device's storage capacity to make sure it's not full.
- Scan your system for viruses or malware.
- Make sure you're using the latest version of your browser.
- Disable any browser extensions or plugins that may be causing conflicts.
- Disable any firewall or antivirus software temporarily to see if they are causing conflicts.
- Reset your browser to its default settings.

If no solutions are found:

- Submit an issue for the bug on our repository via https://github.com/Blankeos/scoliovis/issues
- Contact one of the developers of ScolioVis via the emails provided on page 17 of this manual.



FAQ (Frequently Asked Questions)

Q. Why is the model not part of the GitHub repository when cloning?

> The reason why the model is not included in the GitHub repository when cloning is because the model is quite large in size, at around **225.72 MB**. Including such a large file in the repository would not only make it harder to manage but also slow down the cloning process for users. Instead, the model can be downloaded separately from a release on GitHub and then placed in the appropriate directory. This also allows for easier updates to the model without having to update the entire repository.

Q. Does scoliovis-api download the model automatically?

> In fact, we use a file storage service similar to Amazon S3 called Deta. The model is stored there and is automatically downloaded if you have the environment variable `DETA_ID=<key>` inside the .env file of scoliovis-api. However, for privacy and security reasons, the key is not disclosed publicly or in this manual.

Q. Can I change the port number that scoliovis-api runs on?

> Yes, you can change the port number by specifying a different port number when running the server with uvicorn. For example, `uvicorn main:app --port 8080` will run the server on port 8080.
>
> **HOWEVER!** Keep in mind that **scoliovis-web**, the frontend, fetches from http://localhost:8000/v2/getprediction by default. You can change this behavior by putting the following in the .env file of scoliovis-web: (Do this when you're hosting for production as well)
>
> ```
> NEXT_PUBLIC_UPLOADFILEAPI=http://localhost:8080/v2/getprediction
> ```

FAQ (Frequently Asked Questions)

Q. When I upload my spine image, is it saved on your server?

> Rest assured, your data is 100% safe because we don't save anything on any database. In fact, we don't have any!

Q. How was the model trained?

> We used a Keypoint RCNN model on PyTorch trained on the SpineWeb Dataset 16 which contains spinal anterior-posterior x-ray images.

Q. Can ScolioVis work on other types of X-ray images besides anterior-posterior spine X-rays?

> No, ScolioVis is designed specifically to work with anterior-posterior spine X-rays. Other types of X-ray images will not be compatible with the tool.

Q. What file formats does ScolioVis support for uploading images?

> ScolioVis supports common image file formats, including JPEG, PNG, TIFF, and BMP. However, no PDFs.

Q. Does ScolioVis require an internet connection to work?

> Yes, ScolioVis requires an internet connection to work, as it is a web-based application.

Q. Can I use ScolioVis on my mobile device?

> Yes, ScolioVis is accessible through any web browser, including those on mobile devices. However, it is recommended that you use a desktop or laptop computer for the best experience.

Q. How can I interpret the results provided by ScolioVis?

> ScolioVis provides a visual representation of the Cobb angle measurement on the uploaded X-ray image. The actual values of the different sections of the spine are also indicated.

Q. Does ScolioVis replace radiologists?

> No, ScolioVis is not meant to replace radiologists. ScolioVis is designed as a screening tool to aid in the measurement of Cobb angles on anterior-posterior spine X-rays. The tool is intended to assist radiologists and other medical professionals in making a diagnosis but is not a substitute for the expertise and judgment of a qualified medical professional.

Q. Is ScolioVis suitable for diagnosing scoliosis, or is it only intended for screening purposes?

> ScolioVis is intended for screening purposes only and should not be used as a substitute for a medical diagnosis. The tool provides a measurement of the Cobb angle, which is an important factor in diagnosing scoliosis, but a qualified medical professional should be consulted for a comprehensive diagnosis.

Q. How do I cite ScolioVis in my research or publication?

> We'd love you to cite our research work! We recommend going to our repository at https://github.com/blankeos/scoliovis and go to the citation section of our documentation where we have formats for APA, MLA, etc. Here's a sample **APA Citation** below:

```
Taleon, C., Elizalde, G., & Rubinos, C. (2023).
  ScolioVis: Automated Cobb Angle Measurement on
  Anterior-Posterior Spine X-Rays using Multi-
  Instance Keypoint Detection with Keypoint RCNN.
  West Visayas State University College of
  Information and Communications Technology.
```

The Dream Team Behind ScolioVis

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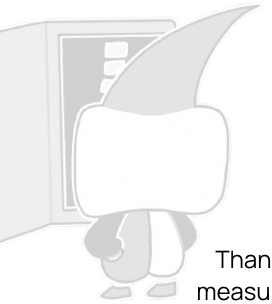
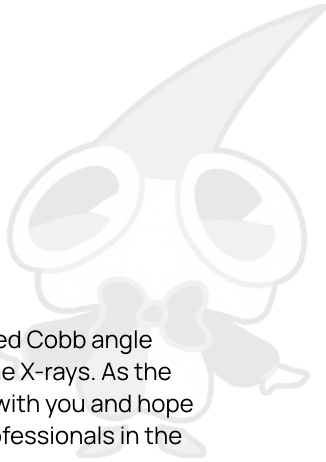
Resources

Web App
https://scoliovis.app/

Source Package (Detailed Documentation)
https://www.github.com/blankeos/scoliovis

You have reached the end of this manual.
Thanks for reading!





Author's Note

Thank you for using ScolioVis, the automated Cobb angle measurement tool for anterior-posterior spine X-rays. As the creators of this tool, we are excited to share it with you and hope that it will be a useful resource for medical professionals in the assessment of Scoliosis.

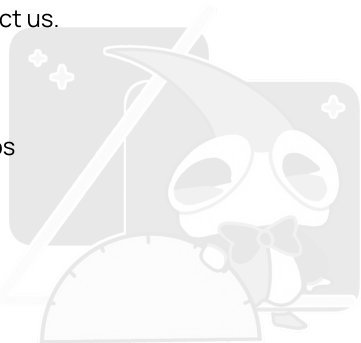
This tool is the result of months of hard work, research, and development, and it would not have been possible without the contributions of many individuals and institutions. We would like to extend our thanks to the SpineWeb Dataset 16 and the Accurate Automated Spinal Curvature Estimation (AASCE) 2019 Grand Challenge, particularly to Dr. Shuo Li for providing us with the data and evaluation metrics that made it possible to train and evaluate the model.

I would also like to acknowledge the support of our thesis advisors, Dr. Frank Elijorde and Dr. Bobby Gerardo, as well as the experts we consulted, Dr. Julie Ann Salido, Mr. Paolo Hilado, Dra. Jocelyn F. Villanueva, Dr. Christopher Barrera who provided invaluable guidance and feedback throughout the project. Finally, I would like to thank the users of this tool, whose feedback and input will help to improve and refine ScolioVis in the future.

We hope that ScolioVis will be a valuable resource for medical professionals and will contribute to the assessment and treatment of Scoliosis. If you have any feedback, questions, or concerns, please do not hesitate to contact us.

Thank you,

Taleon, Elizalde, and Rubinos
The ScolioVis Team



ScolioVis

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