

A Platform for Classifying Melanoma

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Summery

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Motivations:

- ◀ Enhance AI¹ knowledge.
- ◀ Automation as way to democratize access to research and AI solutions.
- ◀ CAD² system are promising path towards medical automation.

¹Artificial Intelligence.

²Computer-Aided Diagnosis.

Objectives:

- ▶ Gain expertise in deep learning theory and its real-world applications.
- ▶ Explore and study the optimal approach for utilizing the distribution of dermoscopy images from the dataset during the training process.
- ▶ Propose and train deep learning models using transfer learning on ISIC³ Challenge melanoma images.
- ▶ Create an easy deployment CAD infrastructure running in Docker, with the trained models, a user-friendly web UI⁴ and a HTTP API⁵.

³Skin Imaging Collaboration.

⁴User Interface.

⁵Application Programming Interface.

Problem

Detection of Melanoma Skin Cancer

- ◀ Melanoma exhibits a high mortality rate.
- ◀ Dermoscopy procedures are utilized for melanoma detection.
- ◀ Dermoscopy images are examined by professionals to study cutaneous lesions.
- ◀ Several studies have shown that melanoma task classification using CAD systems achieve comparable or superior results to dermatologists.

Metastasis

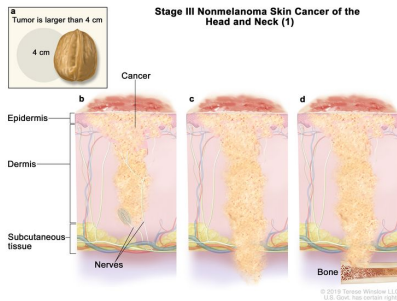


Figure 1: Skin Cancer, Stage III. Illustration by Terese Winslow

Solution

CAD Training and Deployment Pipeline

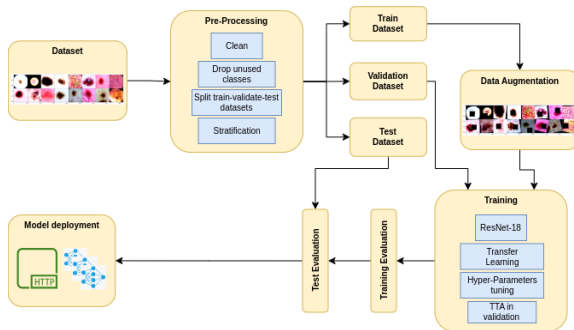


Figure 2: CAD Infrastructure Pipeline.

Micro-Service Architecture to Infer Images

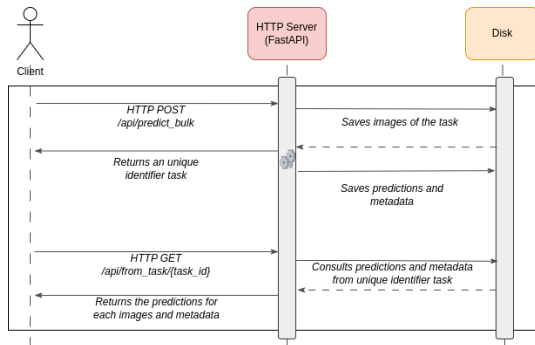


Figure 3: *Inferring Images Through the Background Task Mechanism.*

Ethical Concern:

- ◀ The solution employs "black box" models, lacking explain-ability.
- ◀ The thesis presents a CAD tool designed to aid human decision-making rather than being an autonomous decision-making system.

Regulatory Framework:

- ◀ When dealing with medical images, obtaining signed consent is necessary for data publication.
- ◀ Recent research collaborations prioritize data sharing through de-identification methods to tackle these challenges.
- ◀ The thesis made use of the ISIC Archive database, which serves as a publicly accessible resource.

Origin Data Description:

- ◀ The data originates from the ISIC Archive.
- ◀ It includes images from the years 2019 and 2020.
- ◀ The images are available in three different resolutions: 512x512, 768x768, and 1024x1024 pixels.
- ◀ The dataset contains more than eight distinct classes.

Used Data Description:

- ◀ Resolution selected: 512x512 pixels.
- ◀ The used dataset comprises 31,265 distinct image samples.
- ◀ Eight classes were selected to work with.
- ◀ Imbalanced dataset.

Classes Distribution in the Dataset

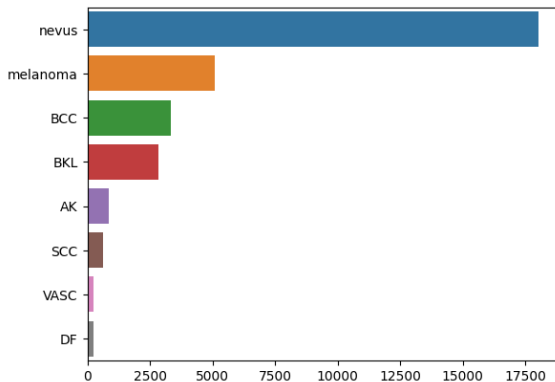


Figure 4: *Data Distribution.*

Train, Validation and Test Sets

- ▶ The dataset was stratified to ensure an equal distribution of classes in each subset.
- ▶ The training set was created using 80% of the dataset, the validation set using 10%, and the test set using the remaining 10%.

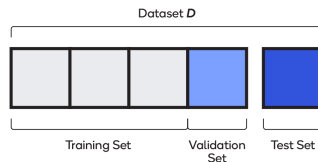


Figure 5: *Holdout Set Scheme. Illustration by Qualcomm*

Data Augmentation

The train dataset (Figure 6),

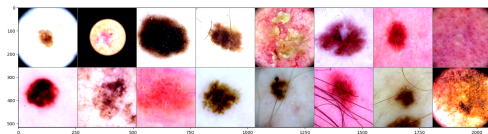


Figure 6: *Random Sample of Images.*

Is mapped into an augmented train dataset (Figure 7).

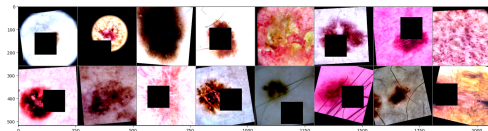


Figure 7: *Augmented Random Sample of Images.*

The TS fuzzy model can be justified by:

- ◀ Its simplicity
- ◀ Uncertainties
- ◀ Its acceptable accuracy
- ◀

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The system can be modeled as:

$$\begin{cases} {}^C D^\alpha x(t) = f(x(t), x(t - \tau(t)), u(t)), t \geq 0, \\ x(s) = \varphi(s), s \in [-\tau, 0] \end{cases}$$

$x(t) \in \mathbb{R}^n$ the system state

$u(t) \in \mathbb{R}^m$ the control vector

τ : the delay

System behavior without controller

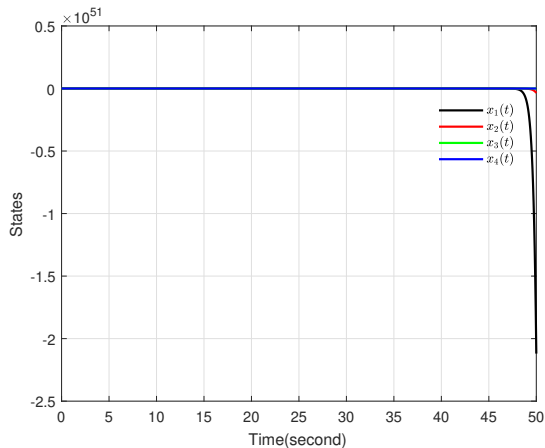


Figure 8: System state

System unstable

System behavior with controller

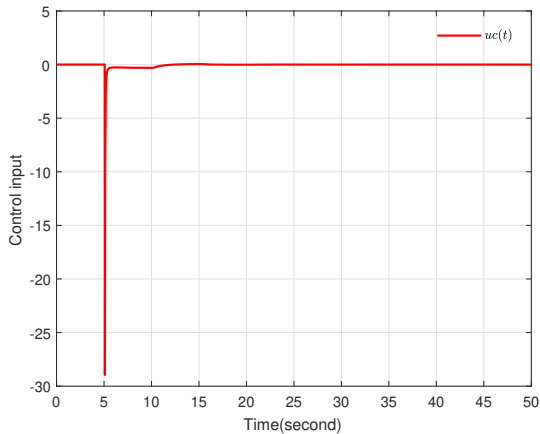


Figure 9: Control signal

System behavior with controller

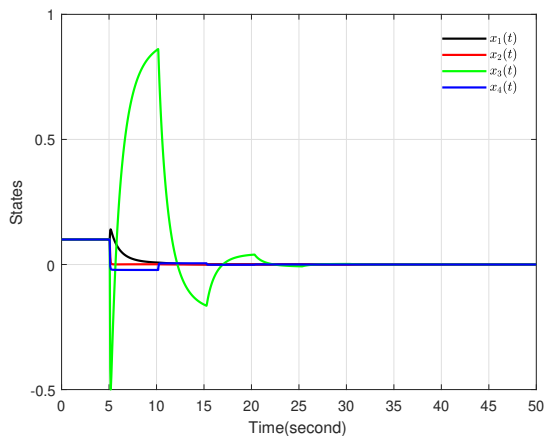


Figure 10: System state

The system is stable but it needs more enhancement

System behavior with the proposed controller

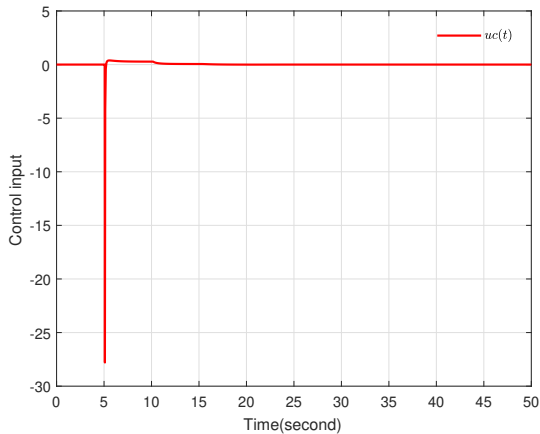


Figure 11: Proposed controller signal

System behavior with the proposed controller

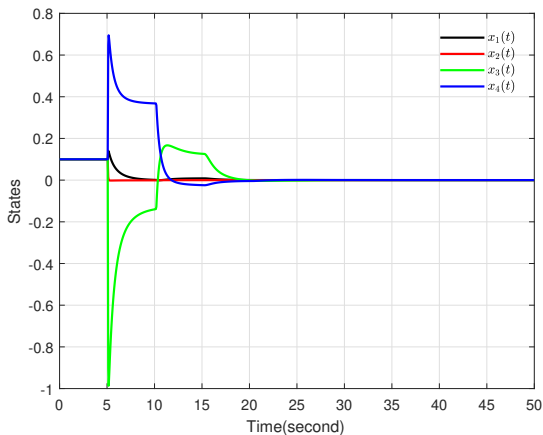


Figure 12: System state with the proposed controller

Stability + better performance

Quantification of the comparative study

	Classical controller	Proposed controller	Enhancement rate
Settling time	26	20	23 %
Pic to pic x_3	1.36	1.16	15 %
$\int_0^{ts} (x_3^2) dt$	2.5540	0.7771	70 %
$\int_0^{ts} (u^2) dt$	12.8476	7.1868	40 %

Table 1: Quantification of the comparative study

We remark that

- ◀ **Enhancement of the settling time of 23%**
- ◀ **Reduction of the control energy by 40%**
- ◀ **Overall enhancement by 70%**
- ◀ **Pic to pic reduction by 15%**

We conclude that:

Conclusion

- ◀ **Lyapunov method efficiency.**
- ◀ **Proposed controller leads to better performance.**
- ◀ **Delayed controller enhances the performance.**
- ◀ **Proposed approach allows reduction of the control energy.**

As perspectives we propose:

perspectives

- ◀ Perspective 1.
- ◀ Perspective 2.
- ◀ Perspective 3.