A Platform for Classifying Melanoma

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Summery

Motivations:

- Enhance AI[1] knowledge.
- Automation as way to democratize access to research and AI solutions.
- CAD[2] system are promising path towards medical automation.

[1] Artificial Intelligence.
[2] Computer-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 ISIC[3] Challenge melanoma images.
- Create an easy deployment CAD infrastructure running in Docker, with the trained models, a user-friendly web UI[4] and a HTTP API[5].

[3] Skin Imaging Collaboration.
[4] User Interface.
[5] Application 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

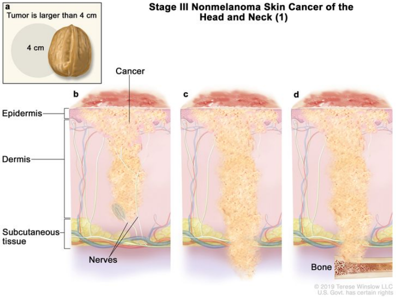

Figure 1: *Skin Cancer, Stage III. Illustration by Terese Winslow*

Solution

CAD Training and Deployment Pipeline

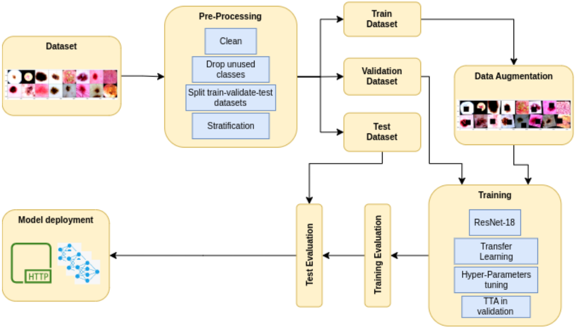

Figure 2: *CAD Infrastructure Pipeline.*

Micro-Service Architecture to Infer Images

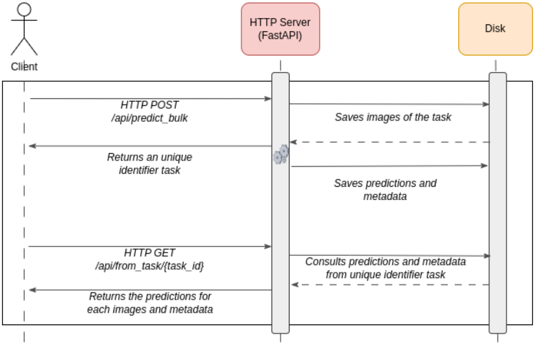

Figure 3: *Inferring Images Through the Background Task Mechanism.*

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 Decription:

- 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 Decription:

- 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

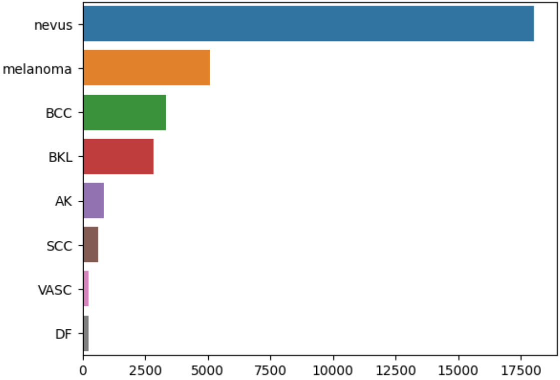

Figure 4: *Data Distribution.*

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%.

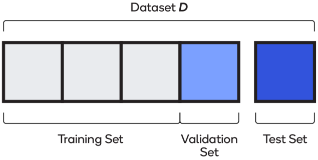

Figure 5: *Holdout Set Scheme. Illustration by Qualcomm*

Data Augmentation

The train dataset (Figure 6),

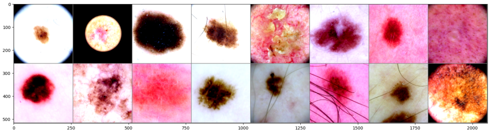

Figure 6: *Random Sample of Images.*

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

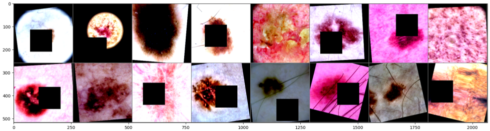

Figure 7: *Augmented Random Sample of Images.*

The TS fuzzy model can be justified by:

- Its simplicity
- Uncertainties
- Its acceptable accuracy
- ....

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The system can be modeled as:

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

$x(t) \in \Re^{n}$ the system state
$u(t) \in \Re^{m}$ the control vector
τ: the delay

API

UI

Containers

- Easy to maintain.
- Portable.
- Fast to start-up.

System behavior without controller

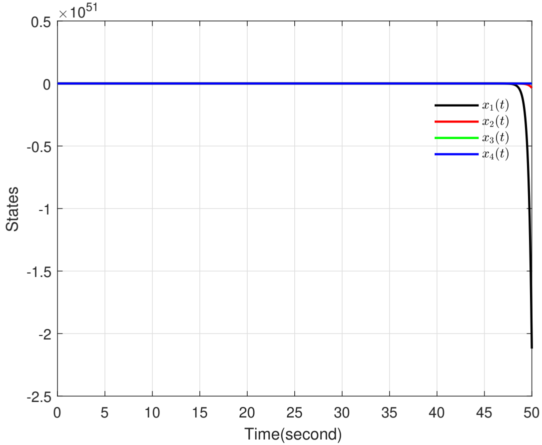

Figure 8: System state

System unstable

System behavior with controller

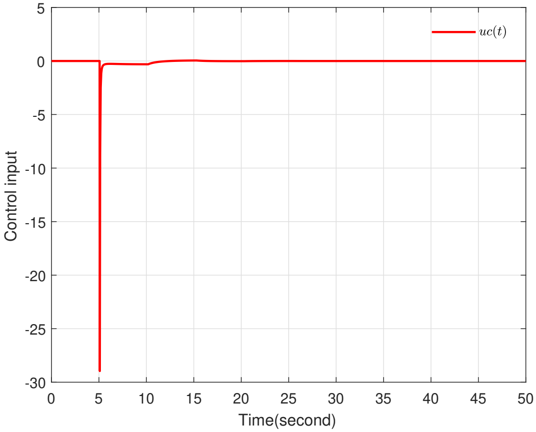

Figure 9: Control signal

System behavior with controller

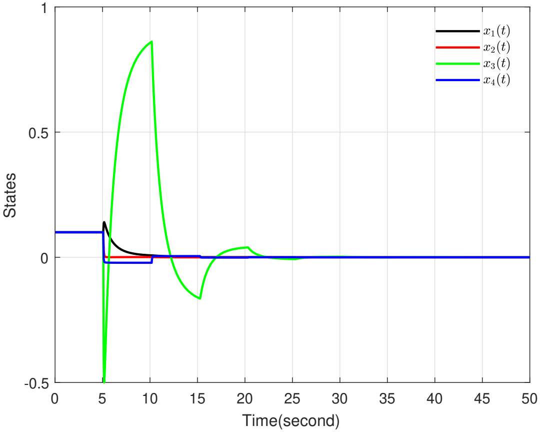

Figure 10: System state

The system is stable but it needs more enhancement

System behavior with the proposed controller

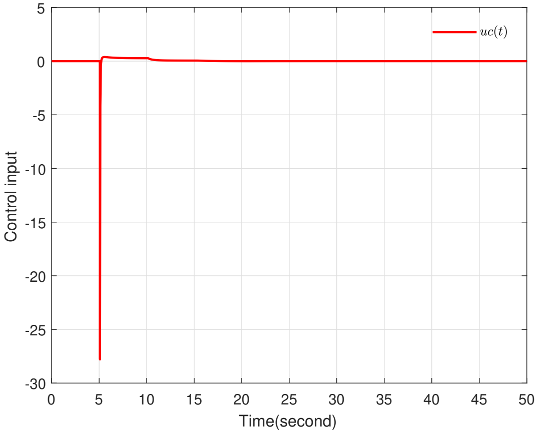

Figure 11: Proposed controller signal

System behavior with the proposed controller

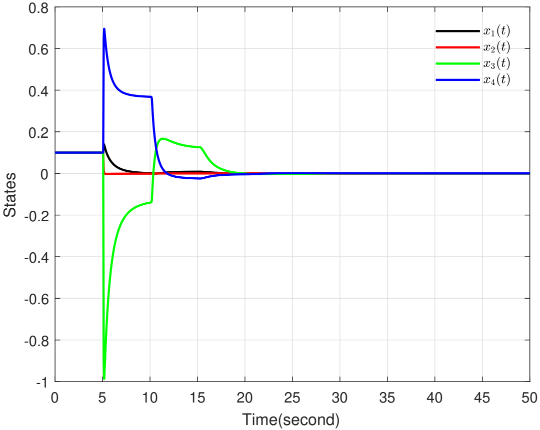

Figure 12: System state with the proposed controller

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.