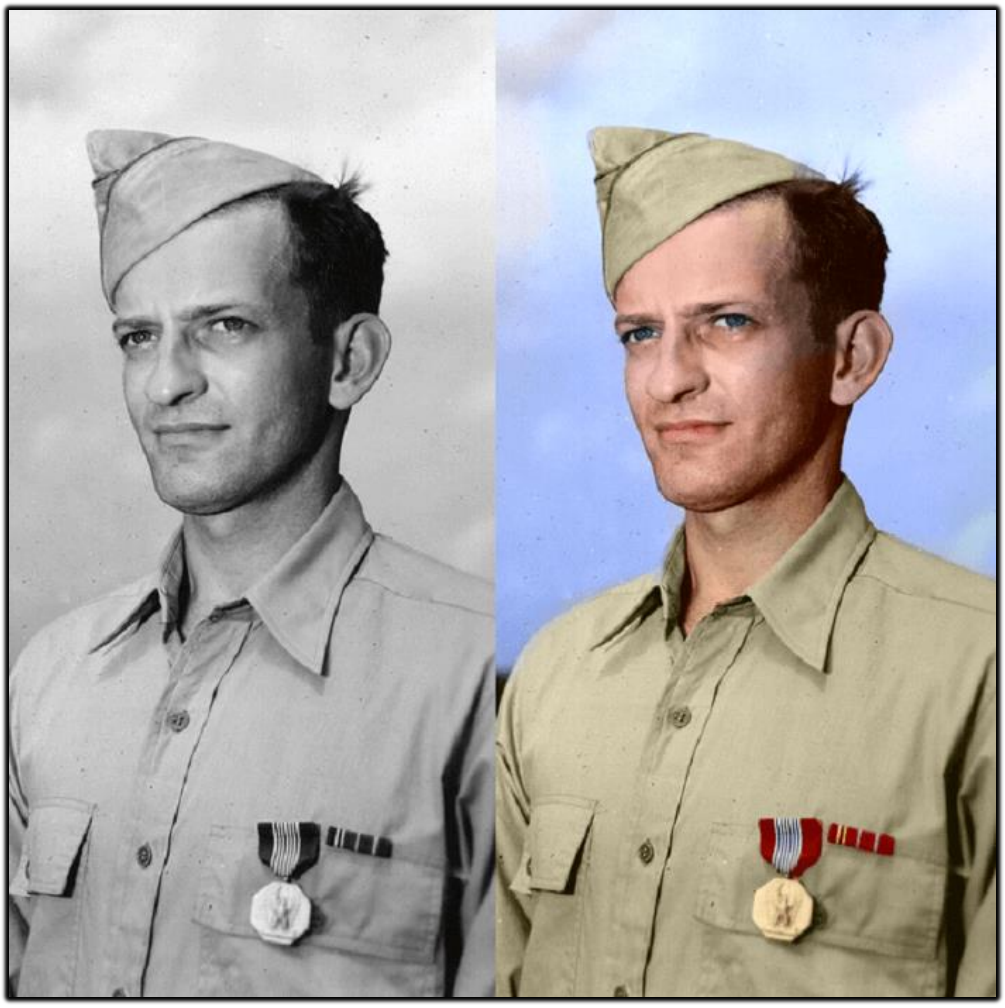
# Project Proposal document

## Colourizing B&W Images



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# Version management

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| **0.2** | 12-03-2021 | Mickey Krekels | Added Domain understandig |
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| **0.9** | 10-05-2021 | Mickey Krekels | Added a conclusion on the Impact Assessment Conclusion (after project), and added some more context to the questions. |
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# Domain Understanding

## Project goal

The goal of this project is to convert black and white images into colored pictures. This AI could be used to add color to old pictures when at that time the option for color was not available in photography. If the project turns out the be efficient, it could even be used to color old films.

The possible drawback of choosing this kind of project is the long computing time while training. But this can be made shorter by using smaller image samples for training.

### The Project Questions

*Main questions:*

Can an AI predict the next colour for each pixel in a black and white image?

*Sub questions:*

1. How to train the AI?
2. What would the target vector be?
3. How are color deified in an digital image?
4. What is the target group?
5. How to predict different sized pictures?
6. What dataset is going to be used?

# Context understanding

This part of the document will explain the idea and the possible problems I could face during this genuine challenge.

## History of B&W Photography

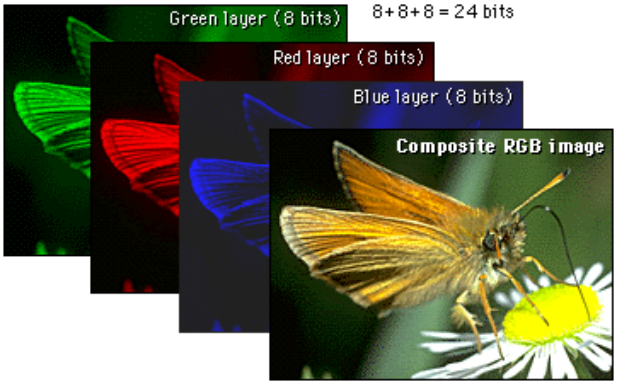
The generally accepted first images ever made is the “View of the Boulevard du Temple” made by Louis Daguerre in 1838(see image below[left]). This Picture was black and white and used a photographic process techniques called daguerreotype. In 1861 the first image with color was created by James Clerk Maxwell called “an image of a tartan ribbon”( see image below[Right]), but it would not become common until the 1960s.

So for my project, the target group are the picture that was taken between 1838 and 1960, with a few exceptions like the experiment of James Clerk Maxwell and other scientists.

## How are the colours in images stored?

### *RGB layers*

Images stored there color values in RGB layers, the term stands for “RED GREEN BLUE” these 3 hues are combined to create different colors. On a computer, the RGB of a picture is usually stored in memory as a 2D array or a raster map. The amount of stored information of each pixel in an image is about 24 bits (8 bits per color layer).




Each of the color layers has values span from 0 to 255, this value determines the brightness of the hue in that grid. That means that AI needs to predict 3 layers of colors that combine the overall shade of the picture.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### *LAB layers*

The LAB color space defines colors differently. Where RGB defines color by a combination of red, green, and blue values, the LAB uses three different channels. They are categorized in: Lightness, The A Channel( red-green), and the B Channel( blue-yellow).the Channel A and Channel B range from the values −128 to 127.When combined the channels, Lightness, A , and B are shortened to L-A-B, Hence the name LAB.

## What Is AI image colourization?

Image colorization is created by using a deep learning model that has been trained on pairs of color images with their grayscale equivalent. After training a large amount of time, the model learns how to add color back to black and white images.

## How to train the model?

### *variance*

It can be difficult for the model to train with just a training set of people, for example when a person is standing in a forest or lake it ca be hard for the ai to figure out the color of something that it is not trained for. To make the model flexible with types of image colorization, we need to provide the training set with different world examples. If trained correctly the model will be more capable of producing the accurate coloured result for the black and white picture.

### *feature matrix*

There are a couple of ways to create a good train/test set for the AI, one is to use old photos that other AI already have colorized, and the other is using already existing colored images and turning them grey and using that as the feature matrix.

For this project, I think that using existing colored pictures! there are just more datasets available of colored images. I use the black and white converter to turn the images monochrome and use that as input for my network.

### *target vector*

As I stated In feature matrix, I want to use existing colored pictures as a train/test set. I split the image dataset up into 2 sections: one that turns in to black and white, and one where I don't remove the color. The one where I keep the color I use as the target vector in the network.

## Are there examples of similar projects?

Yes,  this technology is not new. Many companies already have a working image colorizer, for example, has created a Coloring Black and White Photos tool for web developers. And there are also lots of tutorials on how to create a project that has a similar result as the tool from demos algorithmia . But from what I see they all(most) use prebuild libraries for their machine learning, for my project I want to write my own deep learning algorithm.

# Impact assessment

## 1.Impact on society

What impact is expected from your technology?

### 1.1 What is the challenge at hand? What problem (what 'pain') does this technology want to solve?

The main problem I want to solve is to bring new life in to old black and white images. The target group I want to focus on are photos from 1838 to 1960. The specific ‘pain’ I want to solve is giving back the color of old memory or moments from that time the picture was taken.

### 1.2 Can you indicate why you are sure that this technology is solving the right problem?

This technology is not perfect, but it can predict very accurate representations of how the picture would be like in colour. This can bring new life in old or sometimes plane images, this can be helpful for people who want to have a look back in time when that image was taken.

### 1.3 How is this technology going to solve the problem?

It converts B&W pictures into colored images using a feedforward neural network. There are a few ways to create a model for this task (for more information see chapter modelling).

### 1.4 What negative effects do you expect from this technology?

It could predict the wrong color of the skin with certain ethnic groups. To make sure no one gets offended or feels discriminated, using a diverse training set is required.

### 1.5 In what way is this technology contributing to a world you want to live in?

The AI could shine new light on old images and make historical photography and filmmaking more interesting and appealing. I also think it could be nice to see pictures of your ancestors colorized.

### Now that you have thought hard about the impact of this technology on society, what improvements would you like to make? List them below.

The “Impact on society” chapter has made me think more about what the problem is I want to solve. The technology is more a tool than it is an application so to answer the main question from a “Impact on society” point of view is difficult. But the improvement that I want to make for my technology is using a diverse training set so that the predicted color of the image does not make people feel discriminated.

# 2.Hateful and criminal actors

What can bad actors do with your technology?

## 2.1 In which way can this technology be used to break the law or avoid the consequences of breaking the law?

It could be used to colour Nazi propaganda and hateful imagery/film. The AI also does not save the information of the person that creates the image using the tool, so no one can be hold accountable if the technology is misused.

## 2.2 Can you imagine this technology being used to cross personal - or societal boundaries?

Yes, it could be used disrespectfully, for example, it could colour certain uniforms of soldiers differently. This could be used to spread propaganda and lies about certain military groups.

## 2.3 Can this technology be used against certain (ethnic) groups or (social) classes?

Yes, if the network is not properly trained, it could predict the wrong skin color of certain ethnic groups. So a lot of cultural variance imagery is required to make it predict accurately and not offensively due to wrong predictions.

## 2.4 In which way can bad actors use this technology to pit certain groups against each other? These groups can be, but are not constrained to, ethnic, social, political or religious groups.

Most of the images in black and white were from a time where there was lots of racism, sexism, and Ageism. so it is possible to use some of that data against ethnic, social, political or religious groups. The AI does not check for this kind of information. So bad actors could easily misuse this technology.

## 2.5 How could bad actors use this technology to subvert or attack the truth?

For example if they AI wrongly colors the uniforms of soldiers during a fight or a hate crime. It can be used to push the blame to innocent countries or groups. There for it is possible that the technology can be used as a tool for propaganda and using the output to spread lies. But this scenario could only be possible if the AI creates an colored image that is unrecognizable from a real colored picture.

## Now that you have thought hard about how bad actors can impact this technology, what improvements would you like to make? List them below.

There are certainly a couple of ways that bad actors could misuse this AI, but the problem comes down to in what way is the technology that I am creating dangerous. And to answer that question is quite simple, the risk that it is dangerous is very low. Currently there are lots of ways to tell if a picture has been altered, there are even AI programs for that.  And this project ore something similar has already been done by other companies. So if bad actors could truly misuse this technology there would be plenty of opportunities for them to do so. But a problem that could be realistic is, disrespecting/hurting people by predicting wrong colors, there for a varied training set is required!

# 3. Privacy

Are you considering the privacy & personal data of the users of your technology?

## 3.1 Does this technology register personal data? If yes, what personal data?

No, the technology is more or less used as a function, the user gives the AI an input(B&W image) an it provides the user with an output(the image that has its color predicted), so there is no registration required for this technology to work functionally.

## 3.2 Do you think this technology invades someone's privacy? If yes, in what way?

Yes, if they input a private B&W picture without the owners approval it would invade the owners privacy.

## 3.3 Do you think this technology is compliant with prevailing privacy and data protection law and can you indicate why?

Yes, the GDPR protects data that includes: genetic, biometric and health data, as well as personal data revealing racial and ethnic origin, political opinions, religious or ideological convictions or trade union membership. The AI does not use the data to improve itself, it only converts it to the requested color version. The answer to this question is no, it does not violate any of the GDPR laws.

## 3.4 Does this technology mitigate privacy and data protection risks/ concerns (privacy by design). Please indicate how.

No, training the network and converting the input to an output, are two different things. The technology does not improve by converting more images. It is trained and tested with train/test datasets, the data the user enters for converting is not saved or used for other purposes.

## 3.5 In which way can you imagine a future impact of the collection of personal data?

The technology does not own a collection of personal data, but if bad actors would have them they could use this AI to color in these images. But I think that is out of the scope of this project.

## Now that you have thought hard about privacy and data protection, what improvements would you like to make? List them below.

There are no current Privacy improvements to be made for the technology, the technology does not save the data, it only uses the input to create an output. Self learning is not applied during this process.

# 4. Human values

How does the technology affect your human values?

## 4.1 How does your technology affect the identity of users?

It can colour in the face of a user. So by definition, it affects the person's identity. It can also color the background of someone’s home or property, this can also influence the users identity.

## 4.2 How does the technology influence the users' autonomy?

The technology makes decisions on how the image will be colored based on the data where it was trained on, the users therefor only need there B&W picture and the AI tool to properly use it. The end result will be the output images that is accurately colored. So to answer the question , no the technology is not influencing the users' autonomy.

## 4.3 What is the effect of the technology on the health and/or well-being of users?

The technology does not negatively change the persons health and/or well-being, Its main purpose is to have a positive impact on the people that use it. By providing color it gives the images more character and depth. But if the AI would miss color certain ethnic groups, it could affect those peoples mental health by making them feel discriminated.

## Now that you have thought hard about the impact of your technology on human values, what improvements would you like to make? List them below.

With making an AI that reshapes imagery there are always human values that need to be taken in to consideration. Therefor making sure that the network is fully trained, it will provide the user with the best result. So the main improvement I want to make, is adding more variance in the dataset, this insures that the AI will preform as optimal as it can be.

# 5. Stakeholders

Have you considered all stakeholders?

## 5.1 Who are the main users/targetgroups/stakeholders for this technology?

**5.1.1 - Name of the stakeholder**

museums that use B&W imagery

**How is this stakeholder afected?**

for example world war 1&2 or American history museums, a lot of the information in histories museums can look bland. Therefor this technology provides the public that watches this imagery with more context and colour. I think that museums would find great use for this technology.

**Did you consult the stakeholder?**

No

**Are you going to take this stakeholder into account?**

Yes

**5.1.2 - Name of the stakeholder**

Family members

**How is this stakeholder afected?**

Old portraits or family pictures from around 1960 are mostly black and white. The lack of colour is reflected on the person in that image, by returning the colour, it brings back more of the memory's from that specific spot or moment that photograph was taken. I think most of the family's would enjoy that experience.

**Did you consult the stakeholder?**

No

**Are you going to take this stakeholder into account?**

Yes

**5.1.3 - Name of the stakeholder**

Veteran soldiers/pilots/navy (from world war 2)

**How is this stakeholder afected?**

Most of the times before a big missions soldiers in ww2 would make a squad picture. The images from that time where mostly taken with black and white photography, therefor the imagery literally does not paint an accurate representation of what that moment was. I think that for the Veterans, it could mean a lot to see their old team members in colour.

**Did you consult the stakeholder?**

No

**Are you going to take this stakeholder into account?**

Yes

## 5.2 Did you consider all stakeholders, even the ones that might not be a user or target group, but still might be of interest?

**5.2.1 - Name of the stakeholder**

Pascal Dauphin

**How is this stakeholder afected?**

He is my mentor.

**Did you consult the stakeholder?**

Yes

**Are you going to take this stakeholder into account?**

Yes

**5.2.2 - Name of the stakeholder**

Niek Schmitz

**How is this stakeholder afected?**

In charge of phase 2 (provisioning).

**Did you consult the stakeholder?**

Yes

**Are you going to take this stakeholder into account?**

Yes

**5.2.3 - Name of the stakeholder**

Martijn Lamers

**How is this stakeholder afected?**

In charge of phase 3 (machine learning).

**Did you consult the stakeholder?**

Yes

**Are you going to take this stakeholder into account?**

Yes

**5.2.4 - Name of the stakeholder**

John Litseburg

**How is this stakeholder afected?**

Teacher for phase 1 (proposal document).

**Did you consult the stakeholder?**

Yes

**Are you going to take this stakeholder into account?**

Yes

## Now that you have thought hard about all stakeholders, what improvements would you like to make? List them below.

A big part of my target groups consist of military imagery, Because of that the images are most of the time taken in the outdoors. This means that when I create my training set the train images need to have a lot of outdoor references. For example: woodlands, city's ,villages and farmlands to make an accurate prediction on the colors of the view when it was taken.

# 6. Data

Is data in your technology properly used?

## 6.1 Are you familiar with the fundamental shortcomings and pitfalls of data and do you take this sufficiently into account in your technology?

Yes, there might be some potential pitfalls with the datasets. For example the size of the picture or resolution. The input of a standard feedforward neural network is most fixed to specific size, this means that I have to use a scaling function to set the input to a default dimension.  this makes it difficult because scaling an image down an scaling it up again can lead to losing data.

## 6.2 How does the technology organize continuous improvement when it comes to the use of data?

In the final version there wont be any continuous improvement by the application it self, but if the technology fails in certain aspects. It can always be trained with new training data that takes that issue into account.

## 6.3 How will the technology keep the insights that it identifies with data sustainable over time?

The target group for this technology is from the time frame 1838 until 1960(see History of B&W Photography for more information). So there is technically no new data created. But perhaps future technology can create from a low quality origin a better resolution image. Therefor perhaps this technology could be combined into an even better AI. Because this neural network is created as a function this could be easily done, hence it is sustainable over time.

## 6.4 In what way do you consider the fact that data is collected from the users?

To keep improving the network new data is always helpful, the problem is that users cannot improve the network by using only black and white images. The network needs an example picture that shows the AI what the real colors of the original image are, to therefor improve itself. but black and white images lack these target vectors.  So to answer this question is yes I have considered it, but I found out that it would not be useful for the improvement of the network to collect the users data.

## Now that you have thought hard about the impact of data on this technology, what improvements would you like to make? List them below.

I now see that there could be a lot of problems with the resolution of the input images. This can be a problem because not all images have the same size. A possible solution is to scale the input image up in to a lager size and than for the output scaling it down to its original dimensions.  This ensures minimal data loss because your adding data and removing it again. I also found out that collecting data from users is not helpful for my AI, this is because of the target vector issue.  A possible solution is by collecting feedback from the users, this insures that when a predicting problem occurs users can send the result of the image. The network can than be retrained based on the error(wrong predicting example: pink colored trees).

# 7. Transparency

Are you transparent about how your technology works?

## 7.1 How is it explained to the users about how a technology works and how the business model works?

The technology would be present on a website where the users can upload there chosen B&W Image, on the same page there will be an explanation on how the network was trained and how it can reliable predict the colors based on its training. This will make sure that the users know how the network is functioning.

## 7.2 If this technology makes an (algorithmic) decision, how is it explained to the users how the decision was reached?

It is difficult to explain a neural network if you have no experience in AI, therefor it is hard to explain It towards the users. But by providing links towards sources that can explain the background of the algorithmic network, the users that want more information into the background of the networks logic, can find it there.

## 7.3 it possible to file a complaint or ask questions/get answers about this technology?

For complaints yes it is possible, the network can not learn from the users data, so it is very important that when a wrong prediction is made, it can be notified towards the owners of this technology. And the network can than be retrained based on the error in the described complaint.

And if some users have questions about the technology it is also possible to send a mail towards the owner of the technology. But this will not be included in to the project itself.

## 7.4 Is the technology (company) clear about possible negative consequences or shortcomings of this technology?

Yes, a network is never perfect and it cannot predict a color of  a T-shirt that it has never seen before. This can be confusing for users that use this technology, and it can lead to negative feedback from the users. Therefor it is important to inform the user the shortcomings of the network!

## Now that you have thought hard about the transparency of this technology, what improvements would you like to make? List them below.

During this chapter “Transparency” I found out that explanation towards the users is very important. There for if this AI would be used on a website, clarifying the short coming’s and how it produces the output is needed. So the improvement to my technology is providing the user with more information about the background of this AI.

# 8. Future

Did you consider future impact?

## 8.1 What could possibly happen with this technology in the future?

It could be used to highly accurately predict the colour of old films and photos. To the point where it is as good as taking a picture with a modern camera itself.

## 8.2 Sketch a or some future scenario (s) (20-50 years up front) with the help of storytelling. Start with at least one utopian scenario.

People would be able to see historical films and pictures in colour. To the point where the image looks almost newly made. It would be widely used by museums to give the visitors a look back in time on how it used to be. It would also help family's seeing there diseased ancestors in color, and providing more colour/detail in to family trees.

## 8.3 Sketch a or some future scenario (s) (20-50 years up front) with the help of storytelling. Start with at least one dystopian scenario.

People are using the technology to bring new life to fascist imagery and film. And using it the advert there racist groups. The technology is also widely used by dictator governed countries as propaganda, by changing the color of their soldiers uniforms when they perform crimes against humanity, so that they can blame it on the other neighboring regions.

## 8.4 Would you like to live in one of this scenario's? Why? Why not?

I would rather live in the utopian scenario. There the technology is used for its main purpose, helping people add color to old memories and important moments. The reason I would not like to live in the dystopian scenario is that it would be a negative place to be in. Not knowing what groups are lying and seeing so much negativity would not be the intention of this AI.

## 8.5 What happens if your technology (which you have thought of as ethically well-considered) is bought or taken over by another party?

You can never know the full intentions of the party when they bought/taken over this technology. But If it is used for its main purpose they will only improve the quality of this AI and perhaps make it more accessible for the younger generations, by creating for example a mobile app. If it is bought/ taken over by a party with bad intentions it could lead to a dystopian scenario. In any case, the owner should keep the ethically well-considered values into consideration when letting other people continue on with this technology.

## Impact Improvement: Now that you have thought hard about the future impact of your technology, what improvements would you like to make? List them below.

This chapter "Future" has made me think about what will happen when my technology is finished, other party's can use it for other intentions that not a line with the ethically well-considered values. This means that before other people will continue on with this technology the owner should hold these values into consideration, and making sure that the new owners will have this in mind.

# 9. Metaplan

During this research, I worked with the TICT tool to provide questions for the "Potential Impact Assessment". These Questions give me a good starting point of knowing the societal impact of my technology. From this point on I can work further on the "Provisioning" and "Predictions" phases. I also took a look at the IDEO AI Ethics Cards but a lot of the cards were using the same question format that I already covered in the "Potential Impact Assessment", So I decided I would use those cards if I find the need for it during this project. That way if I found some new information regarding "societal impact" I could use it at that stage of the project. To prove that I use the values that I learned during the "Potential Impact Assessment", I will continue improving this chapter by reading research papers and feedback from my teachers.

# 10. Final Impact Assessment Conclusion (before project)

During this "Potential Impact Assessment" I found a couple of improvements that are useful for this project. In chapters: Stakeholders , Hateful and criminal actors , Impact on society and Human values I found out that having diversity in the test/training dataset is really important, predicting the wrong colors can lead to more issues than just a strangely looking image. It can lead to users feeling disrespected or discriminated. An important issue that popped up during chapter Data, is the Image input size. This is a problem that I need to fix during the machine learning phase. But it was very helpful to find it during this process, it gives me more time to think about a possible and reliable solution. And the final possible improvement I want to apply for this project is from chapter Transparency, if the AI is working as intended I could use the code for an API and perhaps add a website to it, where I will describe in detail how the network works. This is more for a future scenario if there is still extra time left, but I thought I would mention it.

# 11. Final Impact Assessment Conclusion (after project)

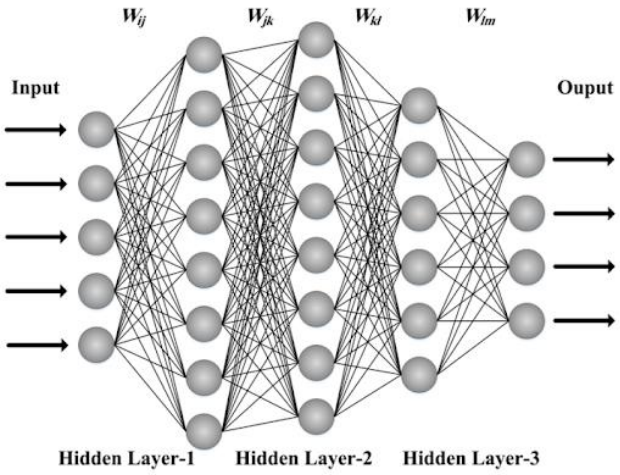
During the finalization of this project I used a lot of improvements and ideas I learned from the "Potential Impact Assessment". One of these improvements used during the Delivery phase, was found during the chapter Data. I found out a problem with the Image input size that I needed to address. While I scale the image to the input size a lot of the detail was getting lost, this was resulting in a blurry image. I fixed this problem by copying the light layer from the original image and pasting the predicted image color spectrums over it. This gave a really detailed and colorful result, and without the "Potential Impact Assessment" I would only found this out at the end of this phase, thus this gave me the opportunity to already think about possible fixes beforehand. In chapters: Stakeholders , Hateful and criminal actors , Impact on society and Human values I used the learned knowledge about coloring ethnic groups and applied it in my Provisioning phase. By training using a trained set with lots of ethnic groups, the AI now does a great job at coloring the skins of people respectively. And finally from chapter Transparency I applied what I learned in my final delivery, by creating a user-friendly tool where people can colorize their pictures. But not everything was used, In the end I did not used the IDEO AI Ethics Cards , I have read the IDEO cards but for this project I thought the TICT tool already provided enough information to answer these important Potential Impact questions.

This is the conclusion of this Impact Assessment, I now know the importance of answering the right Impact questions ahead. It gave me in my project a good structure and room for thinking about potential problems, thus I will use this technique in future projects to come.

# Modelling

## Neural network (V1)

For this project, I am going to apply a neural network using the feed-forward (DFF) technique. The model of the network will consist of: input layer, hidden layers , and an output layer. Depending on the mean squire error(MSE) the best model will be used to produce the final colored output image.




As I described in the part "RGB layers" of this document. I told that the color of a digital Image consists of 3 layers (RED GREEN BLUE) and that it is stored in a raster map with values from 0 to 255. This means that our network has to predict these values to create a colored output.

There are a few ways to handle this problem, number one is to create a network with an input of all the layers stacked on to each other and at the output separate the end result into its own colored layers. And the second option is to create 3 neural networks that are trained based on one of the 3 color layers. And combine the end result to create the hue of the image.

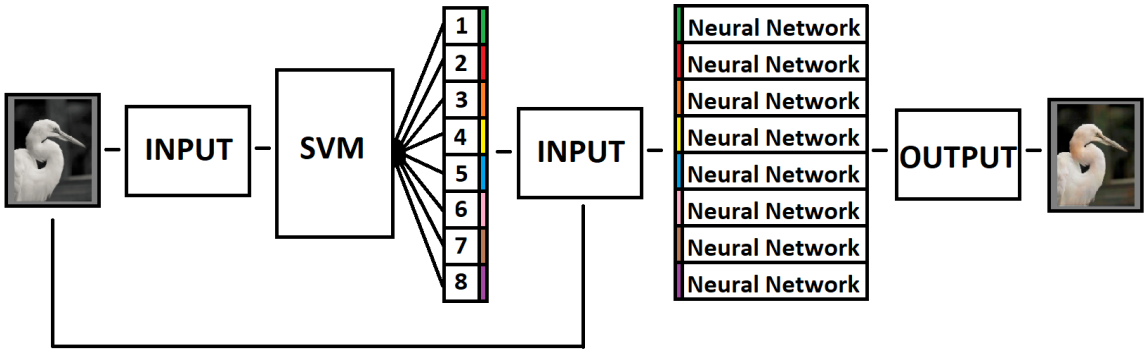
## Neural network (V2)

In the second version, I am going to apply the same neural network using the feed-forward (DFF) technique. The model of the network will consist of: input layer, hidden layers , and an output layer. Depending on the mean squire error(MSE) the best model will be used to produce the final colored output.

The main difference is that this model will predict the LAB color spectrums(see chapter LAB layers for more information). The model only needs to predict the A channel and the B channel, so these layers can be combined in the output or they can be trained separately. The output will be turned back into an RGB image and this will give the colored result.

## Suport Vector Machine (SVM)

For the second AI in this project I am going to use the SVM model to predict  the category of the image. when the picture is classified, the image will go to the second AI, a neural network that is specifically trained to that category. I think this will be a need way to combine these two AI models(see visual example below).




## Flexible input

Not all images are the same size and this could be a problem with an network with a fixed input. There are a couple of ways to handle this issue, the first one is by using a resize function to resize all input images to a fixed dimension, this then will be used as an input to the network. the second option is using a ”Recurrent Neural Network”. The connections between nodes form a directed graph along with temporal order. This allows for a flexible input. The problem with this option, that it is very difficult to make and there is not a lot of reference material on this subject.

The Input also needs to be scaled between 0 and 1. If I do not scale the input it may result in large error gradient values causing weight values to change dramatically. The output will also be predicted between 0 and 1, so reverse scaling also needs to be applied.

# Dataset

The First dataset I am going to use is the “Coco Dataset”. it contains 5000 images, each image has different sized dimensions. The reason I selected this dataset is because of its picture variety . It not only focuses on people but also on other objects, this gives the training set more different scenarios to learn from.

Link: Coco Data set

The second Image dataset is the “FFHQ Faces”, which is from the website Kaggle. This dataset contains 70000 images with an resolution of 128px by 128px. The reason I selected this data set is that the first one contained too many scenery pictures, the dataset also contains a lot of ethnic variation.

Link: FFHQ Faces Data Set

These are the datasets I am going to use and combine during this project. The amount of data and variation of these images are perfect for the current genuine challenge. But there are still some issues I need to address in the provisioning phase.

Problem 1:

The current resolution of the images is not equal in both datasets, the “Coco Dataset has different sized dimension, the “FFHQ Faces Data Set” has a size of 128px by 128px. This means that I have to scale these pictures to the size of the input of the network.

Problem 2:

The first data set has JPG pictures and the second dataset contains only PNG images. This means I have to create a function that converts the image into its corresponding RGB layers, this data will then be saved into a CSV format.

Problem 3:

The images must be turned into black and white pictures to be used as a feature matrix. The original also needs to be separated into the separate 3 color layers (RED GREEN BLUE) in order to be used as the target vector.

If these problems can be fixed these datasets will be ready to be used in the third predictions phase.

# Evaluation and deployment

## Is there a plan for domain knowledge verification?

The project “Colourizing B&W Images” is not a new technology in the AI world, there are quite a few companies that have created a functional Image colorizer. So I know for a fact that the project is doable, also there are some tutorials about picture colorization. There is interesting information in those videos and papers but the main thing they all use are external libraries(mostly sklearn). But for this project, I am going to use my own written neural network.

## What are acceptable evaluation results?

Accuracy of around 85% would be acceptable, the reason that it is not 99 or 100% is that it predicts the color of a certain object or people, therefor overfitting could be a real issue.

## Will the model be deployed? If so, how?

If there is still time left, creating an API would be fun. Python has a requests library and from the examples, I can see that it is fairly simple to use. If that is done I would like to set up a domain using an Azure service.  Or there is also a tool called Anvil, Anvil is a free Python-based drag-and-drop web app builder and that would make It a lot easier to deploy. To answer how will the model be deployed, I have first find out what tool works best.

## Is there a feasibility deduction?

No, every pixel is needed in the network to predict a realistic output. So there is technically no deduction needed in this network.

# Conclusion

After researching this topic “Colourizing B&W Images” I found my answer to the main question (Can an AI predict the next colour for each pixel in a black and white image?) of this proposal document. And the answer is Yes, If I use a neural network that predicts all of the color layers it should create an accurate colored image. For this project, I am going to use a feedforward neural network where I scale the input(black and white image) to a fixed dimension and the output gets scaled back to the original size. For the test and training set I am going to use the datasets from “Image Colorization with U-Net and GAN Tutorial” and “FFHQ Faces”, And I already found some challenging problems that I need to addressed in the next phase . I also now know the possible societal impact that my technology could have, and my target group where it could be used when it is finished.

Therefore I think I am ready and prepared to start working on phase 2, the “Provisioning” part of this project.