SOURCE WATER MONITORING

ENGINEER 2PX3 Team: : Water-48

Prepared by: Antheus Aldridge, Darshini Coore, Yasmine El Khouly, Wenrui He, Syed Ali Zaidi

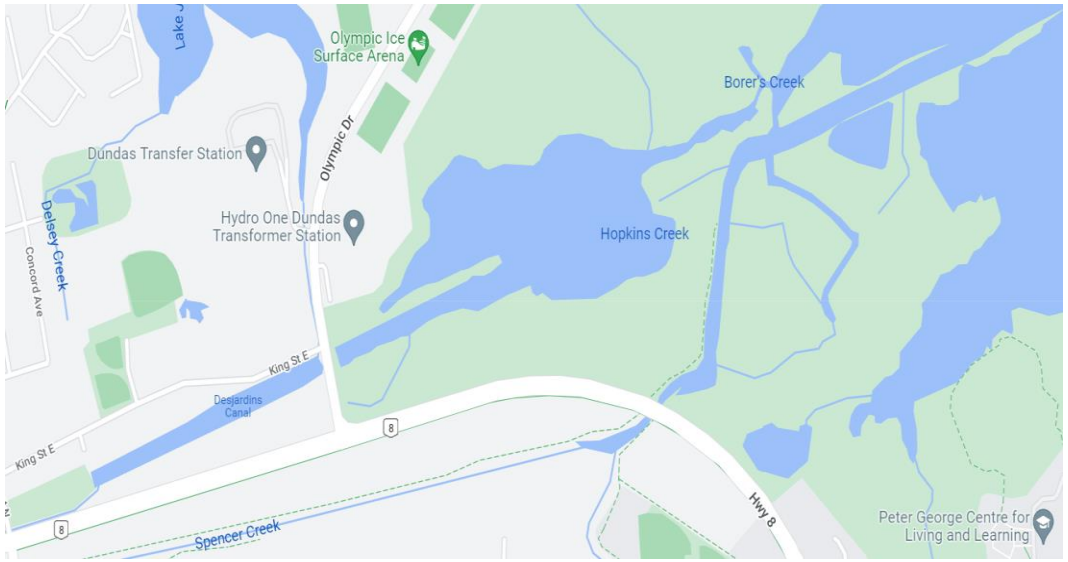
Introduction

- Climate change → more algal blooms
- Cyanobacteria release cyanotoxins
- Important to detect blooms early

Solution Parameters

- Focus on the Hamilton-Halton region of Lake Ontario

- Our solution should:
  - Alert water treatment facilities when a bloom is detected
  - Have a minimal impact on environment
  - Small socio-cultural impact
  - Comply with local and Federal regulations



Stakeholders

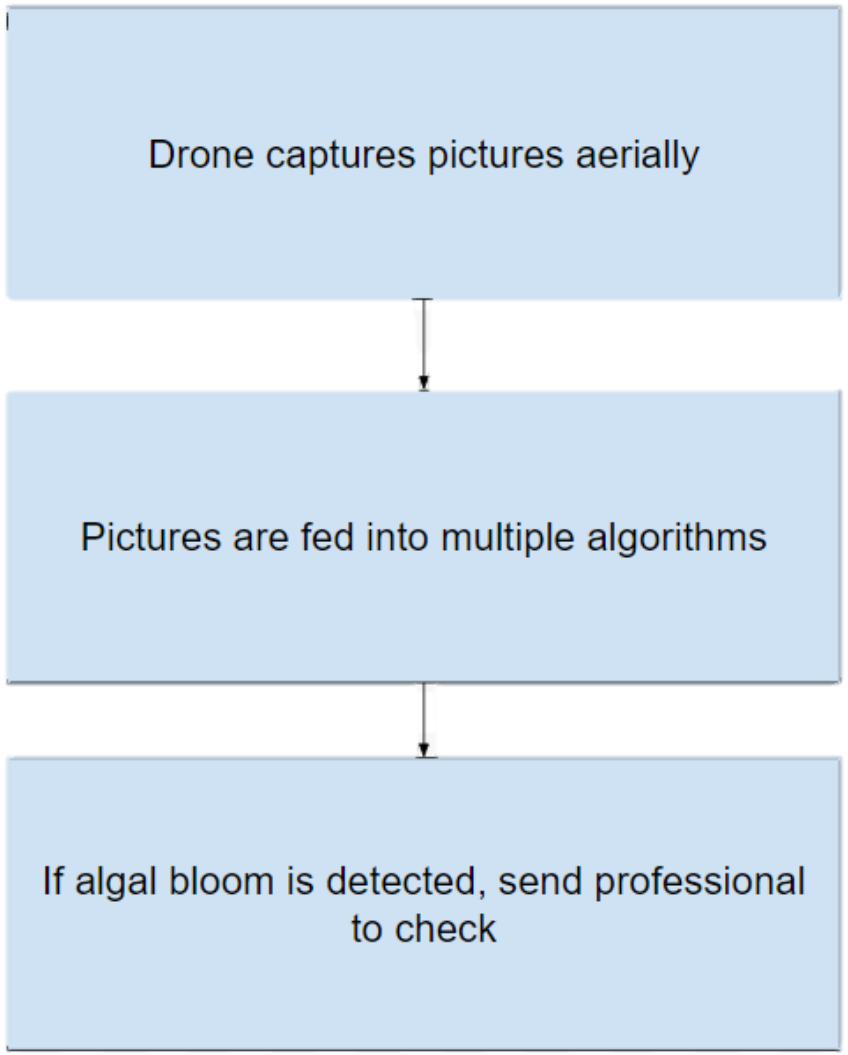
- Stakeholders relate to constraints and parameters of our solution

Primary:

- Water treatment plants → performance constraints
- Wildlife and environmental activists → environmental constraints
- Nearby citizens → socio-cultural and performance constraints

Secondary:

- Tourism Industry
- Fishing Industry
- Drone Manufacturers
- Media Corporations



Our solution

- Use a drone to aerially monitor the lake and capture pictures
- Pictures go through multiple algorithms to detect algal blooms
- If there is a detection, alert water treatment facilities who send out a professional

PERSEID Framework

Performance Constraints

- Acquires large number of high resolution images
- Rechargeable battery and accessible charging station
- Low battery consumption
- Withstand severe weather conditions
- Need to avoid false negatives

$$FP = \frac{1 - 2 \cdot FN}{4 \cdot FN + 2}$$

Selected FN = 5% = 0.05

Environmental Constraints

- Noise Pollution
- Speed limit set when flying over environmentally sensitive areas
- Protects safety of wildlife in instance of collision
- Avoids flying and gliding animals

Regulatory Constraints

- Fly within the height limit
- Must not break any privacy law
- Away from emergency operations and advertised events
- Away from airports and heliports
- Far away from other aircraft
- Survey the area where drone will be flown

Socio-Cultural Constraints

- Flies away from bystanders and residential areas
- Privacy and Data Protection
- Community Surveying and Acceptance
- Protects Safety of People in instance of collision

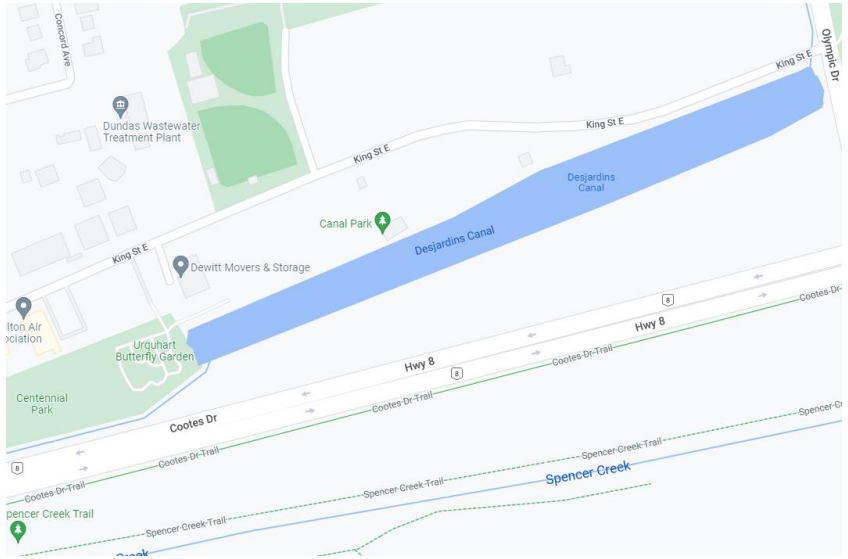
Conflicting Points raised by PERSEID

Conflicting Design Choices (Drone)

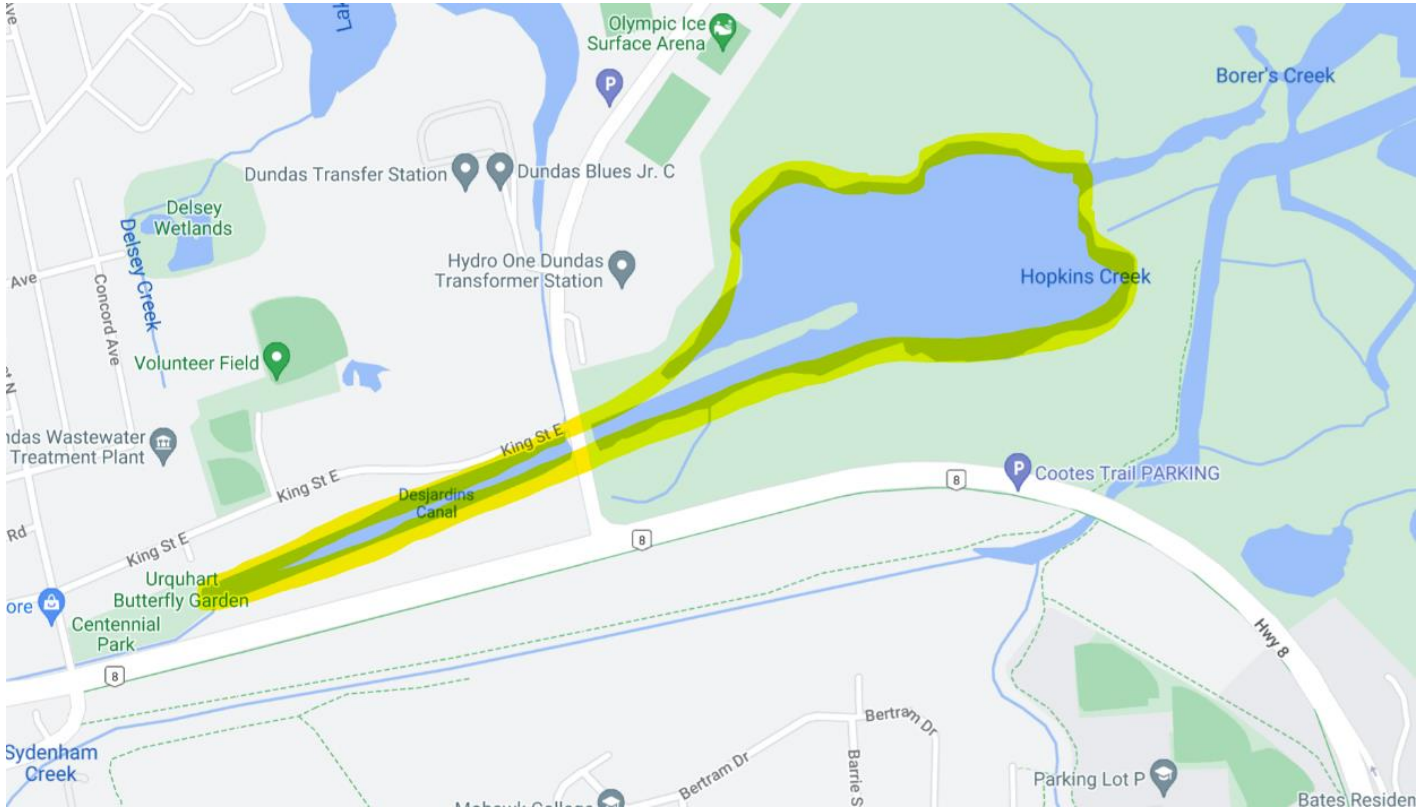
- Pulsing Light on the Drone (Avoid Bird Collision) vs. Maneuverability
- Cage (Avoid Drone Accident) vs. Speed, Maneuverability, Battery life
- Noise Pollution (Silent propellers, Brushless motor, and Noise reduction shrouds and Sand Down the Surface of the Propellers) vs. Speed, Maneuverability, Durability
- Wet Suit vs. Speed, Maneuverability, Battery life
- Weather vs. Speed, Maneuverability

Conflicting Design Choices (Operations and Algorithm)

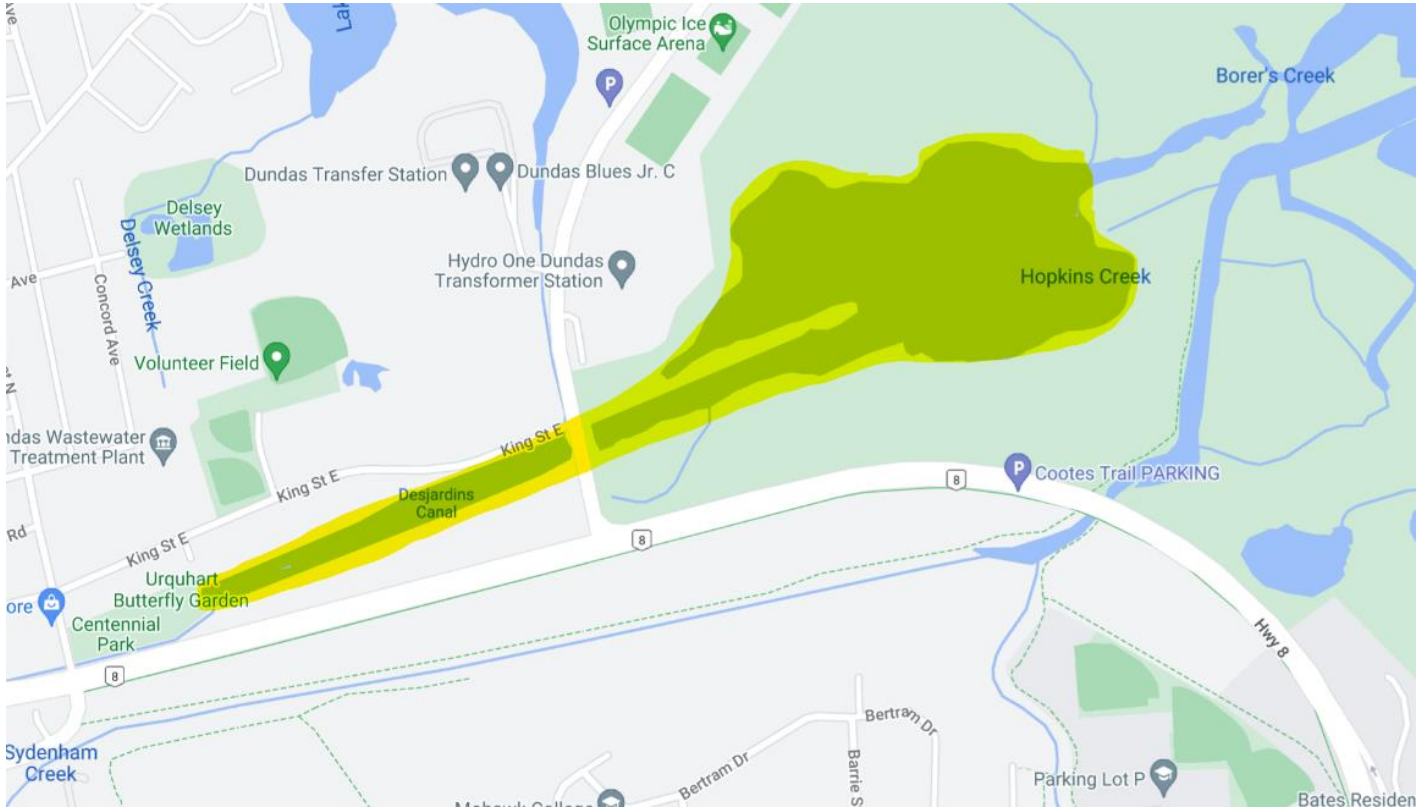
- Number of Images vs. Storage Capacity/Security (SIM/ SD card)
- Number of Images vs. Privacy Concern
- Number of Images vs. Battery Life
- Number of Images/Image Resolution vs. Accuracy, processing time
- Weather vs. Image Resolution
- Speed vs. Image Resolution
- Flight Path/Height vs. Privacy Concern
- Flight Path vs. Battery Life



Design Choices and Decisions


Olympic Ice Surface Arena
Borer's Creek
Dundas Transfer Station
Dundas Blues Jr. C
Delsey Wetlands
Delsey Creek
Concord Ave
Hydro One Dundas Transformer Station
Hopkins Creek
Volunteer Field
King St E
Desjardins Canal
Cootes Trail PARKING
Urquhart Butterfly Garden
Centennial Park
Hwy 8
Bertram Dr
Sydenham Creek
Parking Lot P

Design 1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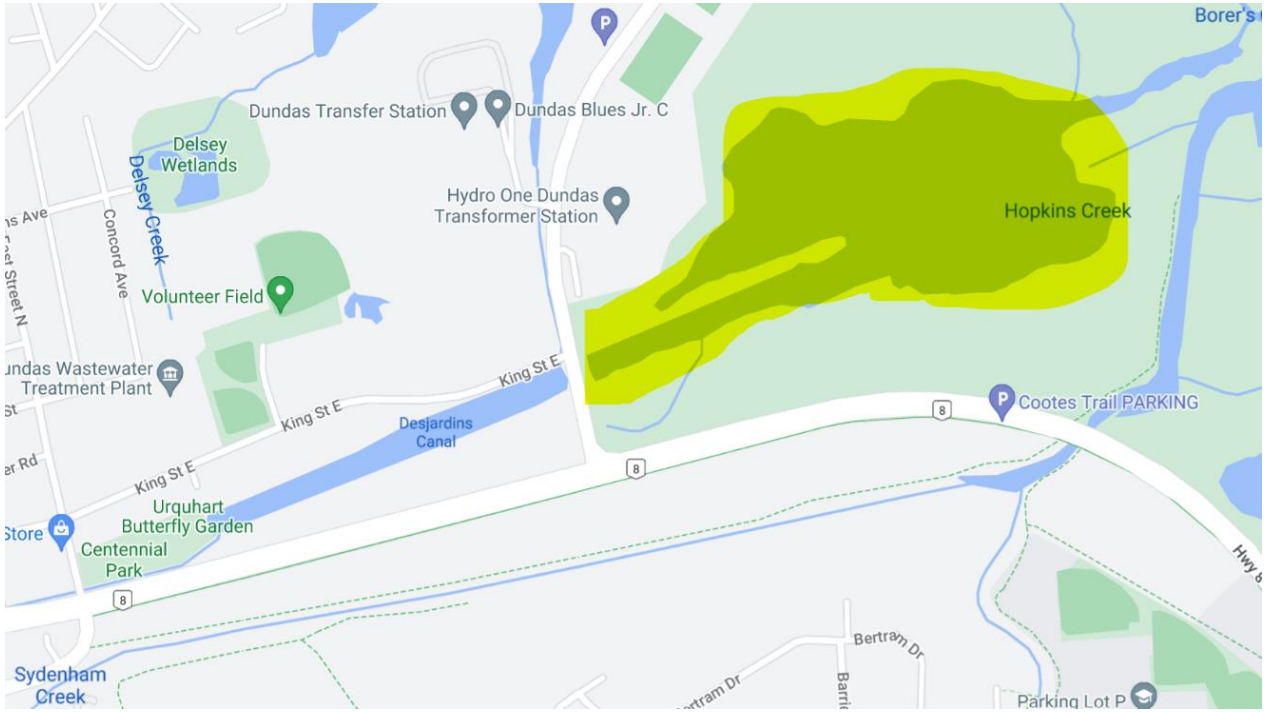
Design 2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Design 3

Technical Decision Matrix

	WEIGHT (1-10)	Design 1		Design 2		Design 3	
Requirements Criteria/Constr.		**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Data Transfer Ease and Security	**8**	2	16	2	16	5	40
Low Battery Consumption	**7**	1	7	3	21	4	28
Maneuverability Preformance to Avoid Obstacles	**6**	2	12	2	12	5	30
Ability to Travel At Hight Speed	**5**	2	10	3	15	5	25
Close Proximity to Flight Path from Charging Station	**7**	5	35	3	21	3	21
Quality and Number of Images Obtained	**9**	5	45	4	36	5	45
Easily Installed Charging Station	**4**	3	12	3	12	5	20
Area of Lake Covered by Flight Path	**10**	4	40	5	50	4	40
TOTAL			**177**		**183**		**219**

Design 3 Ranks Highest

Environmental Performance

	WEIGHT (1-10)	Design 1		Design 2		Design 3	
Requirements Criteria/Constr.		**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Flight Path Avoids Environementally Sensitive Areas	**7**	1	7	2	14	5	35
Reduces Noise Pollution due to Drone System Modifications	**9**	4	36	4	36	2	18
Reduces Damage to Environment in Case of A Collision	**7**	4	28	4	28	2	14
Conspicuousy of Drone to Flying Animals due to Drone System Modifications	**8**	5	40	5	40	2	16
Reduces Likelihood of Crashing Due to Flight Path and Reduced Maneuverability	**9**	1	9	1	9	5	45
TOTAL			**120**		**127**		**128**

Design 3 Ranks Highest

Socio-Cultural Performance

	WEIGHT (1-10)	Design 1		Design 2		Design 3	
Requirements Criteria/Constr.		**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Flight Path Avoids Populated Residential and Commercial Areas	**9**	1	9	2	18	5	45
Reduces Noise Pollution due to Drone System Modifications	**7**	4	28	4	28	2	14
Reduces Likelihood of Capture of Non-Lake Images	**10**	1	10	3	30	5	50
Reduces Damage to People in Case of A Collision	**10**	5	50	5	50	2	20
TOTAL			**97**		**126**		**129**

Design 3 Ranks Highest

Regulatory Performance

	WEIGHT (1-10)	Design 1		Design 2		Design 3	
Requirements Criteria/Constr.		**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Drone is Visibille at All Times Given the Flight Path	**8**	3	24	2	16	2	16
Drone can Easily Maintain a Minimum Horizontal Distance of 30 Metres from Bystanders	**9**	1	9	3	27	4	36
Reduces Requirment to Survey Area (to take note of any obstacles or concerns)	**5**	1	5	3	15	4	20
Reduces Flight Height (is not Required to Fly Close to 122 metres)	**7**	4	28	2	14	1	7
Flight Path Avoids Municipal Areas, Airports and Heliports.	**8**	2	16	5	40	5	40
TOTAL			**77**		**97**		**99**

Design 3 Ranks Highest

Overall Performance

	WEIGHT (1-10)	Design 1		Design 2		Design 3	
Requirements Criteria/Constr.		**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Technical Performance	**5**	177	885	183	915	219	1095
Envionmental Performance	**3**	120	360	127	381	128	384
Socio-Cultural Performance	**4**	97	388	126	504	129	516
Regulatory Performance	**4**	77	308	97	388	99	396
TOTAL			**1941**		**2188**		**2391**

Design 3 Ranks Highest Overall

Model Validation

Testing and Evaluating the Algorithm

Inputs

NUMBER OF ITERATIONS

NUMBER OF IMAGES

IMAGE RESOLUTION

Quality Checks

Loss

Testing/Validation

Training

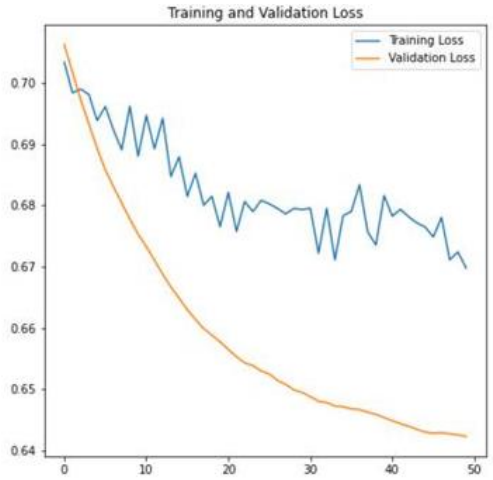
Accuracy

Testing/Validation

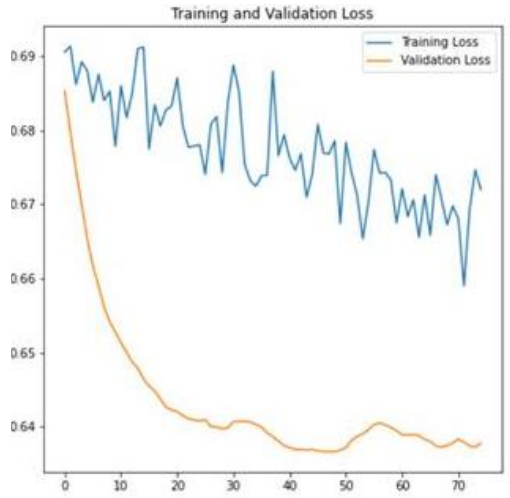
Training

Results

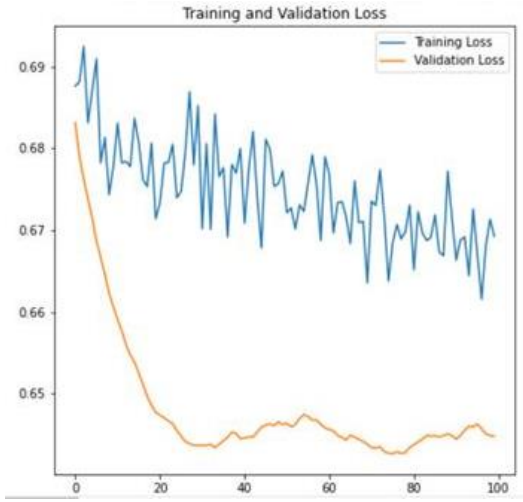
Number of Iterations – Training vs Validation **Loss**



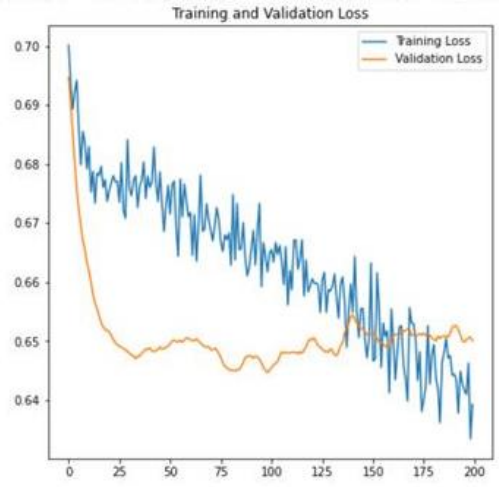
50 Iterations



75 Iterations



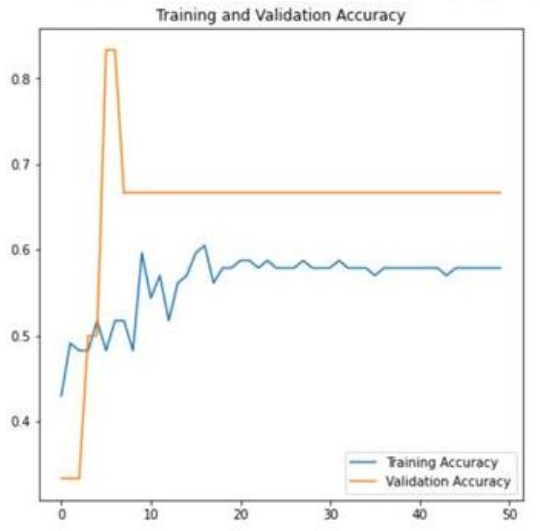
100 Iterations



200 Iterations

Increased iterations → Decreased loss

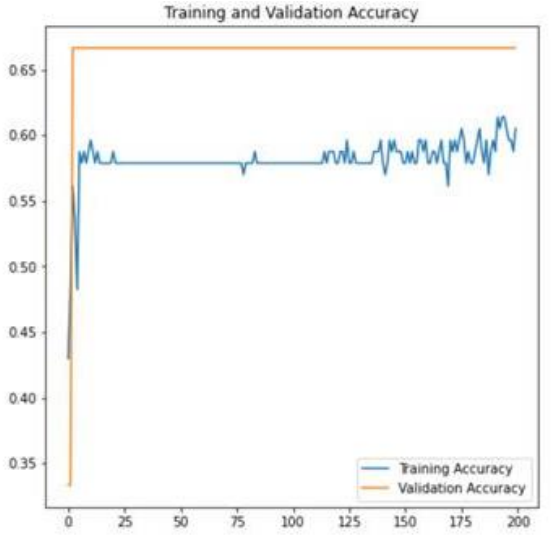
Number of Iterations – Training vs Validation **Accuracy**



50 iterations

75 iterations

100 iterations

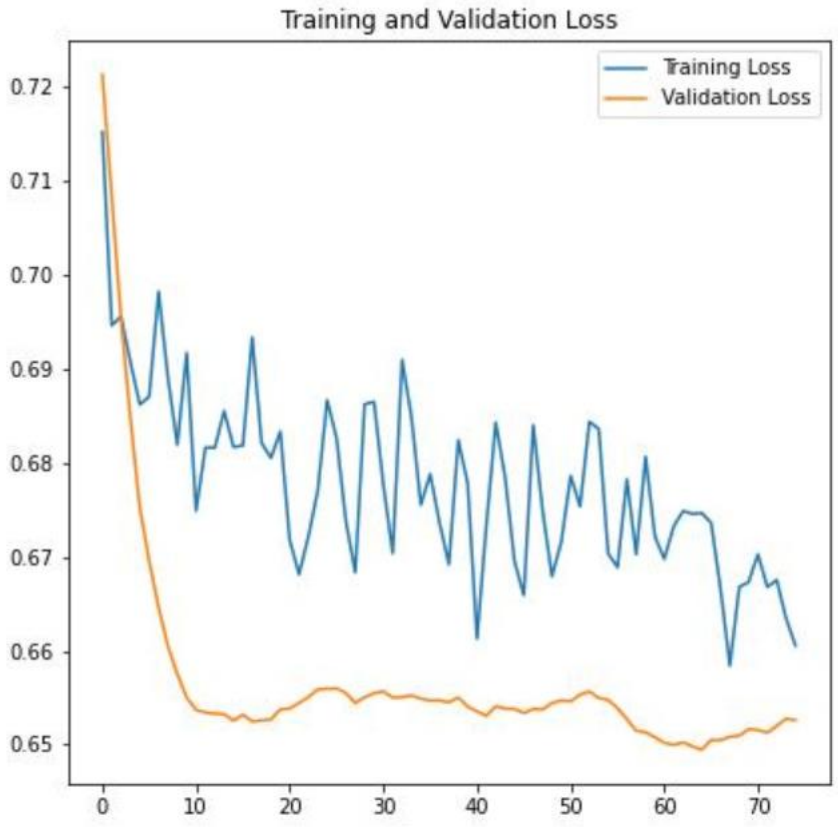


200 iterations

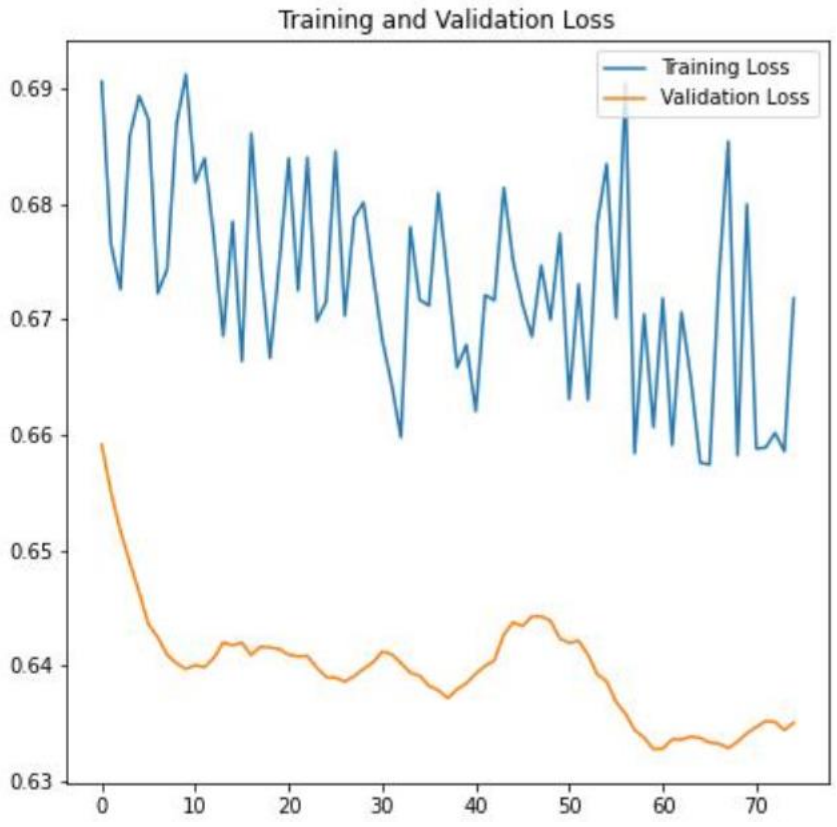
Increased iterations → Increased accuracy

Number of Images – Training vs Validation **Loss**

Original



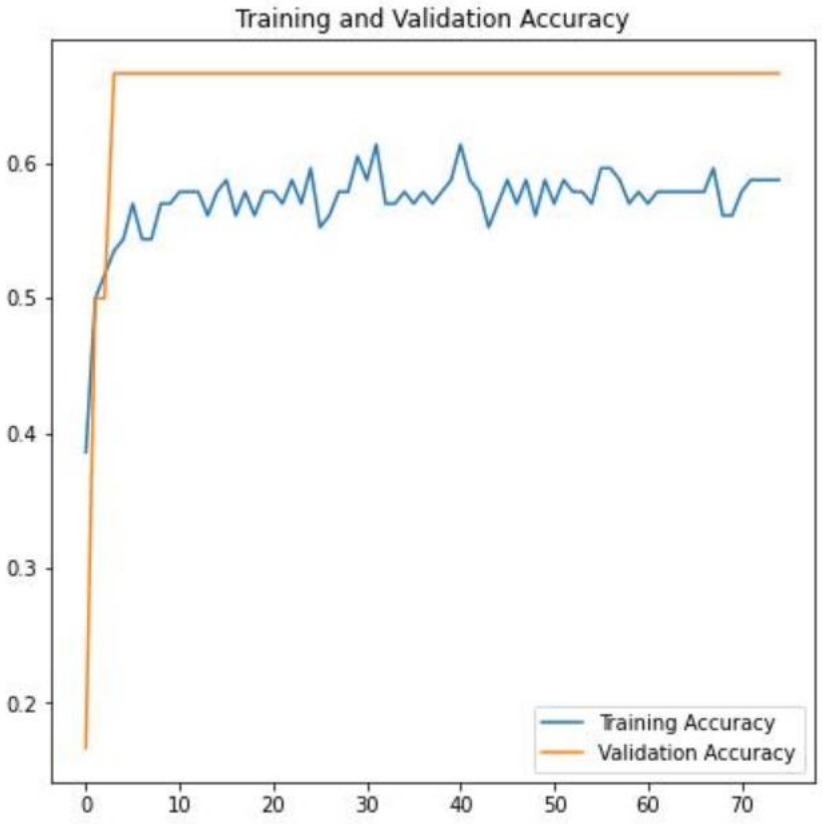
Decreased Images



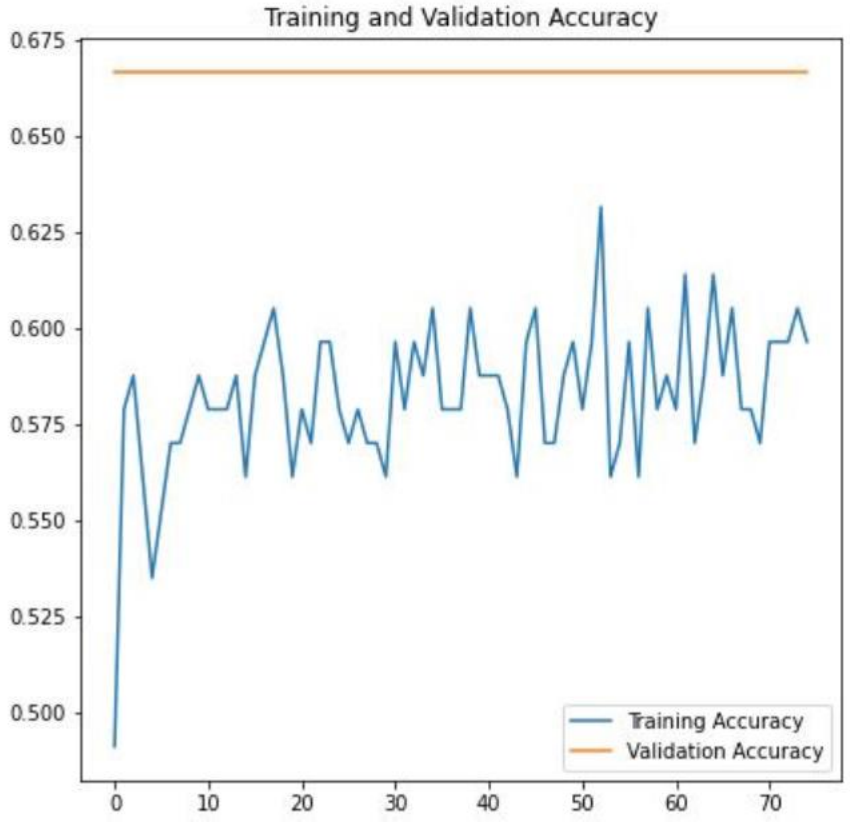
Fewer images → Higher loss

Number of Images – Training vs Validation **Accuracy**

Original

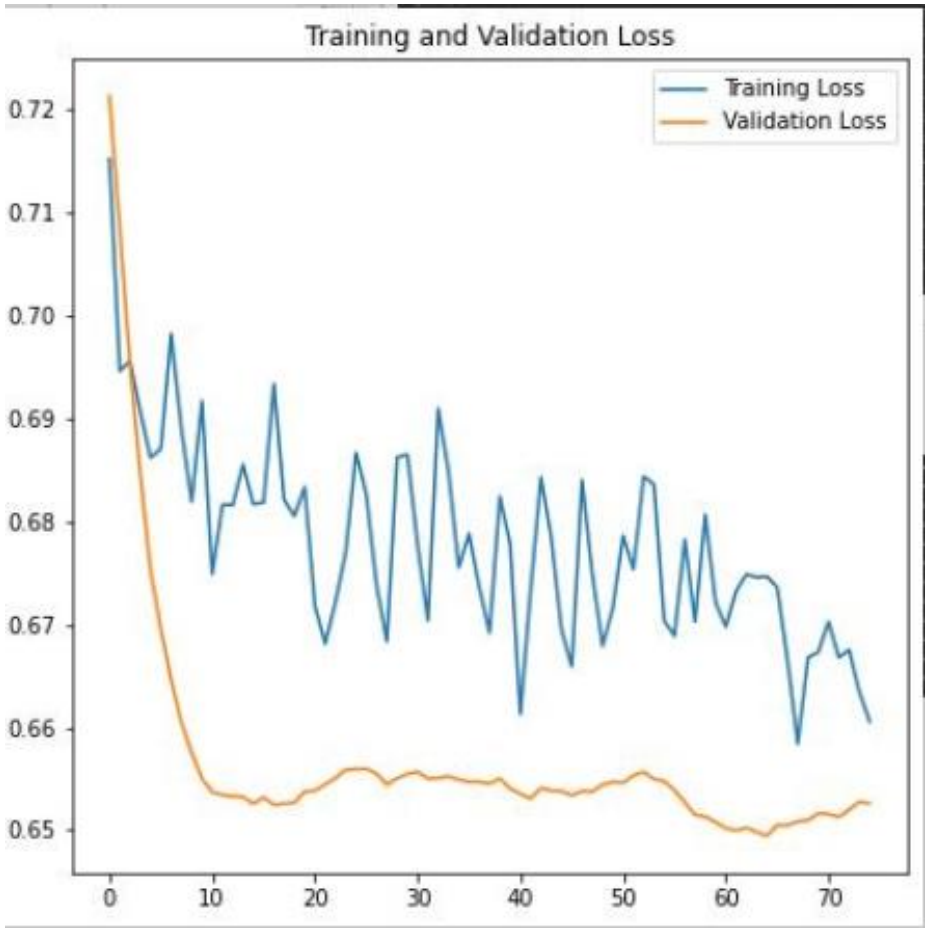


Decreased Images

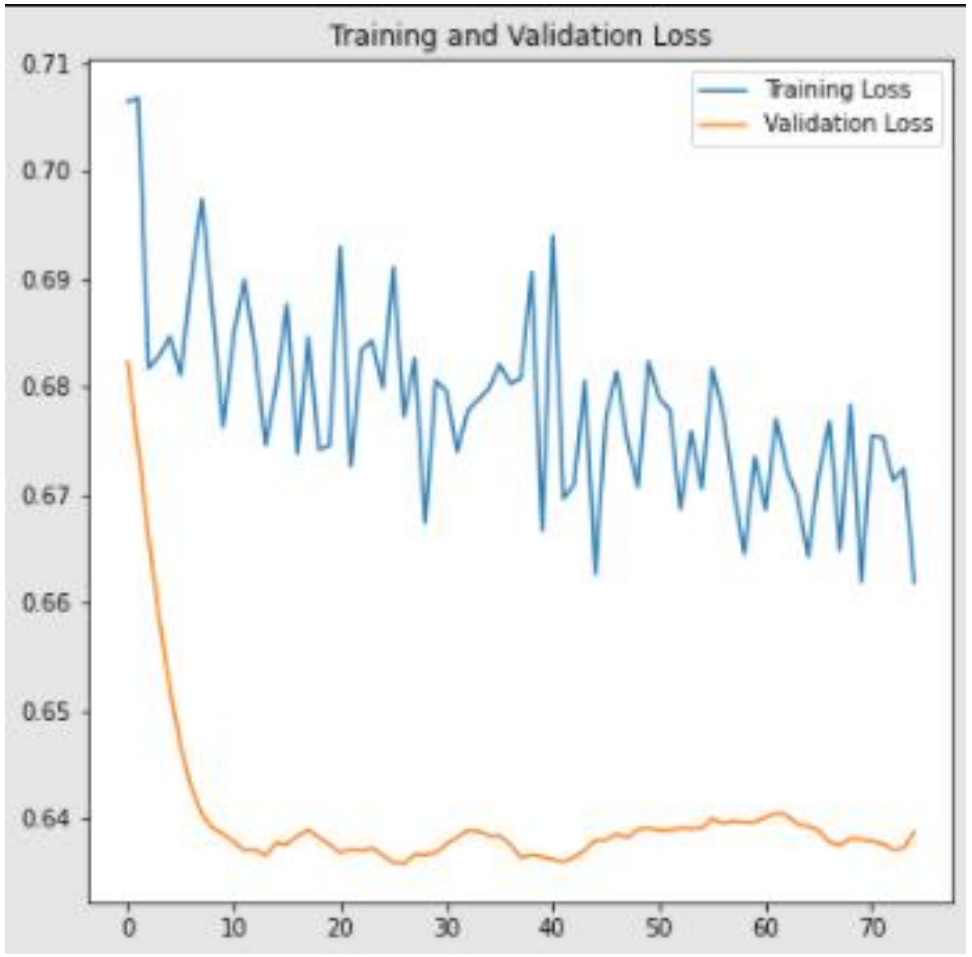


Fewer images → Lower accuracy

Image Resolution – Training vs Validation **Loss**



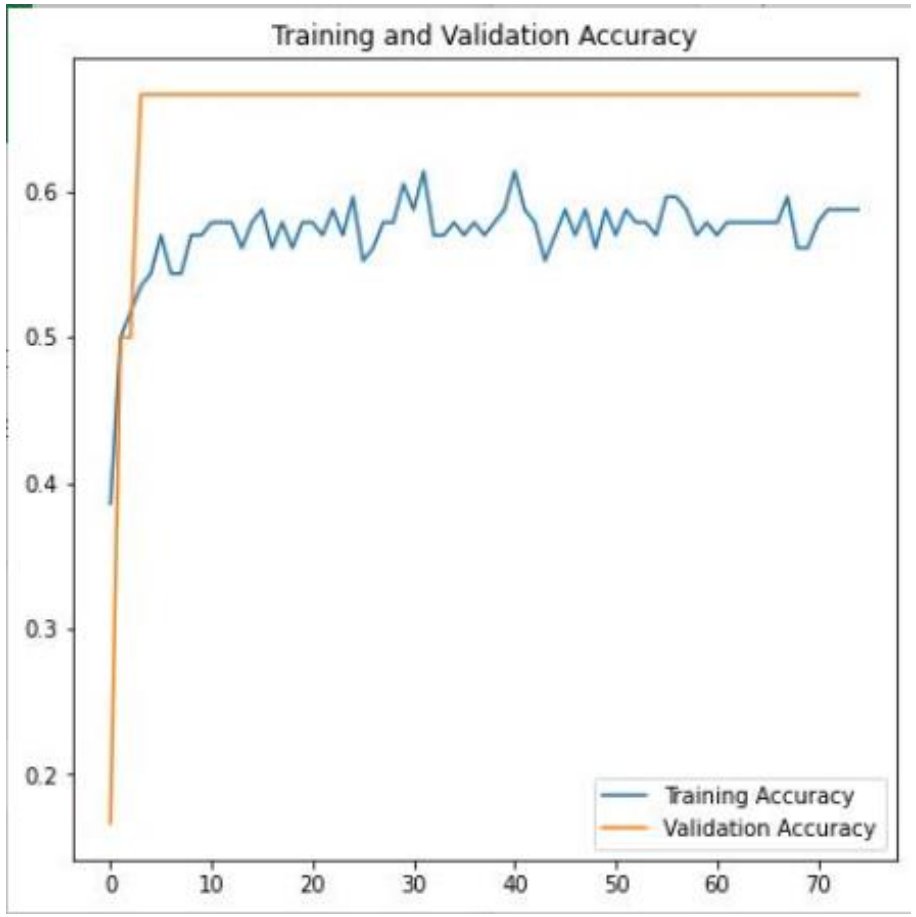
Original



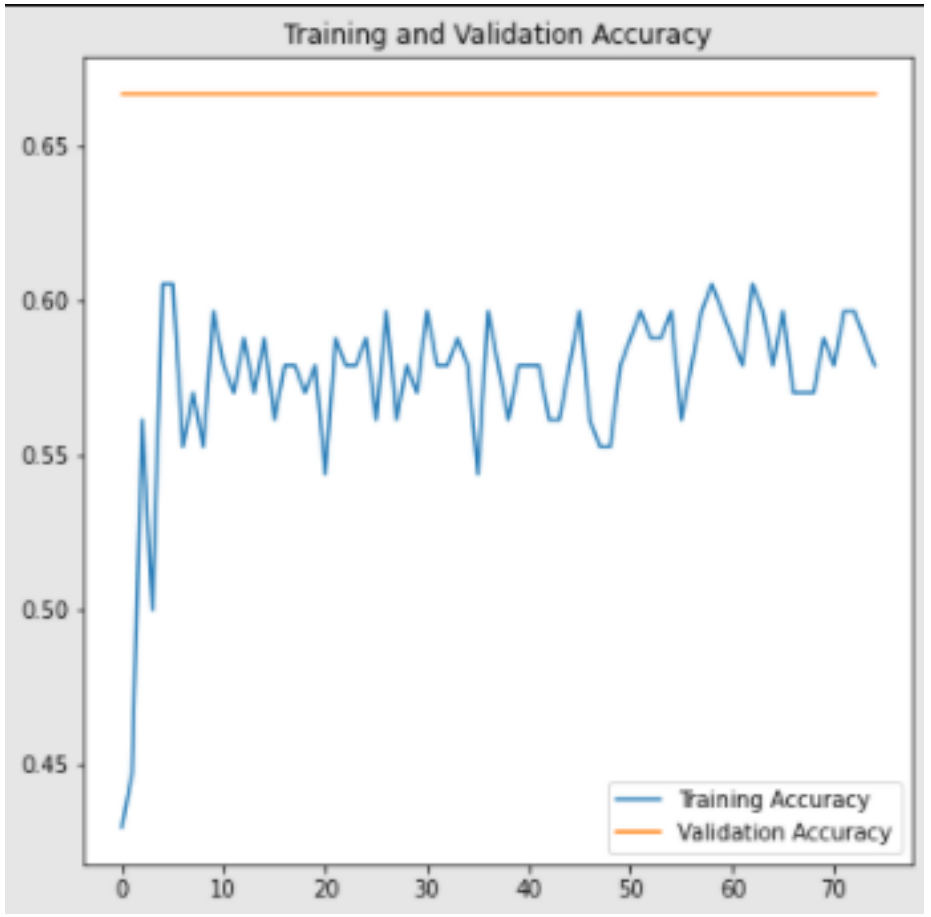
Increased Resolution

Higher Resolution → Lower loss

Image Resolution – Training vs Validation **Accuracy**



Original



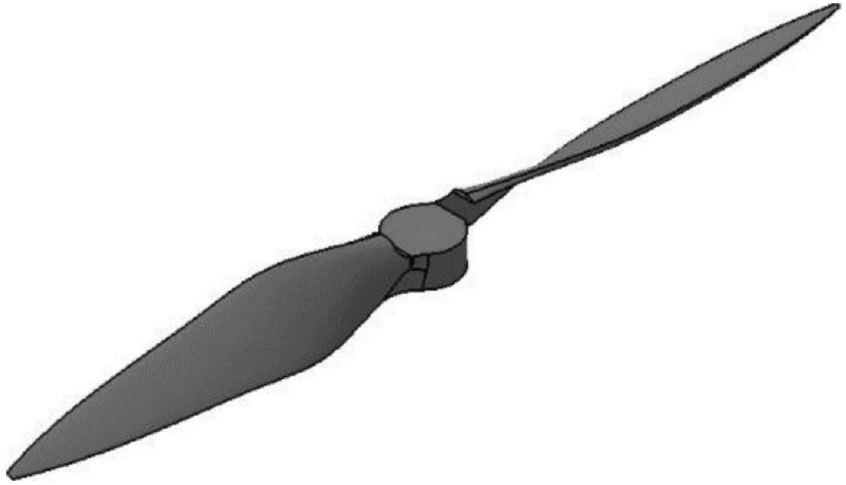
Increased Resolution

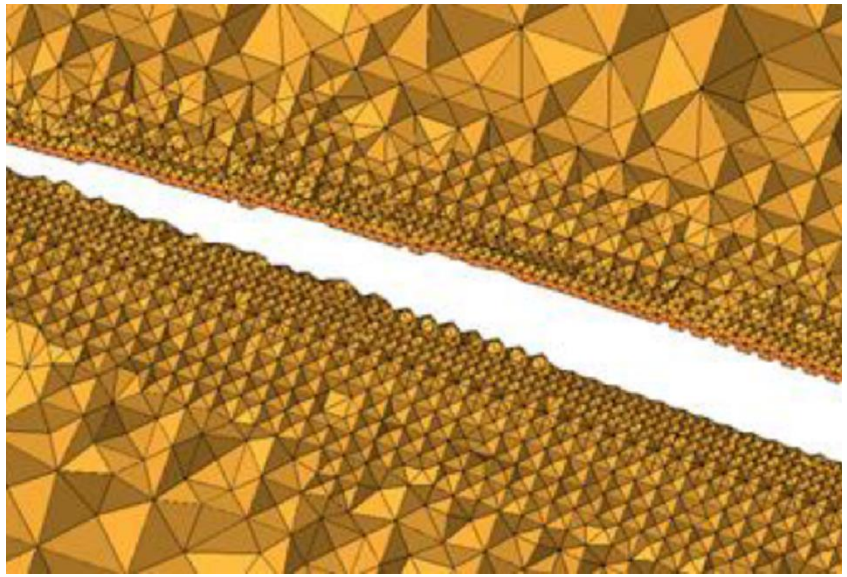
Higher Resolution → Higher accuracy

Final Design

Design 2 + Design 3 + …

- Bright coloured drone
- Blinking light
- Silent propellers (sanding)
- Brushless motors
- Noise reduction shrouds around propellers
- Compliant mesh cage
- Survey of communities in surrounding area





References

- [1] “Project Module - Source Water Monitoring - ENGINEER 2PX3: Integrated Engineering Design Project 2.” https://avenue.cllmcmaster.ca/d2l/le/content/430517/viewContent/3560652/View?ou=430517 (accessed Feb. 05, 2022).
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- [4] “Canadian Aviation Regulations (SOR/96-433).” https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433 (accessed Mar. 12, 2022).
- [5] “Drones in Canada - Office of the Privacy Commissioner of Canada.” https://www.priv.gc.ca/en/opc-actions-and-decisions/research/explore-privacy-research/2013/drones_201303/ (accessed Mar. 12, 2022).
- [6] “Flying your drone safely and legally.” https://tc.canada.ca/en/aviation/drone-safety/learn-rules-you-fly-your-drone/flying-your-drone-safely-legally (accessed Mar. 12, 2022).

Questions?