Advancing Construction Management: Image Processing in BIM Integration & Machine Learning

For NYC Department of Design and Construction (DDC)

NYU Capstone Team Town & Gown

Fall 2023

Project Controls to DDC

Meet Our Team

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Table of Contents

Section I - Current Uses

- Crack Detection
- PPE Detection
- Drones

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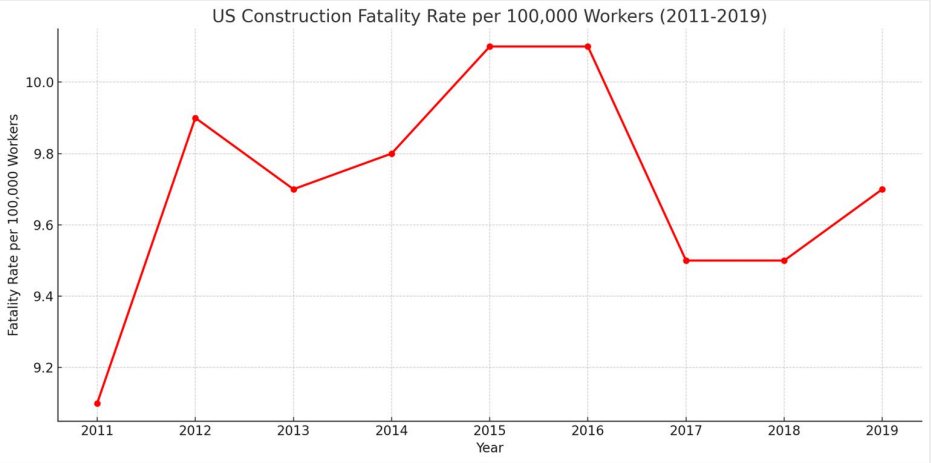
Construction Safety

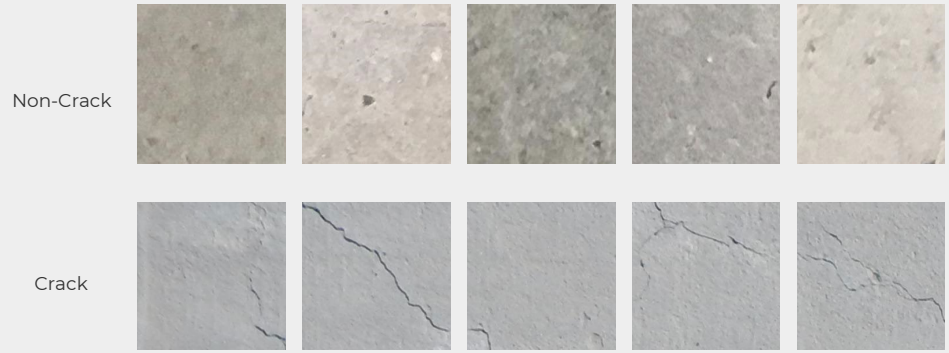
- In 2011, the casualty rate in the construction industry was 9.1, which was the lowest in this period.
- After that, the casualty rate gradually increased, reaching 9.8 in 2014 before peaking at 10.1 in 2015 and 2016.
- Starting in 2017, the casualty rate declined slightly and stabilized at around 9.7 by 2019.



Engineering News-Record. (2020). Construction Jobsite Deaths, Fatality Rate Climb. Retrieved from https://www.enr.com/articles/50940-construction-jobsite-deaths-fatality-rate-climb

Crack Detection

DataSet

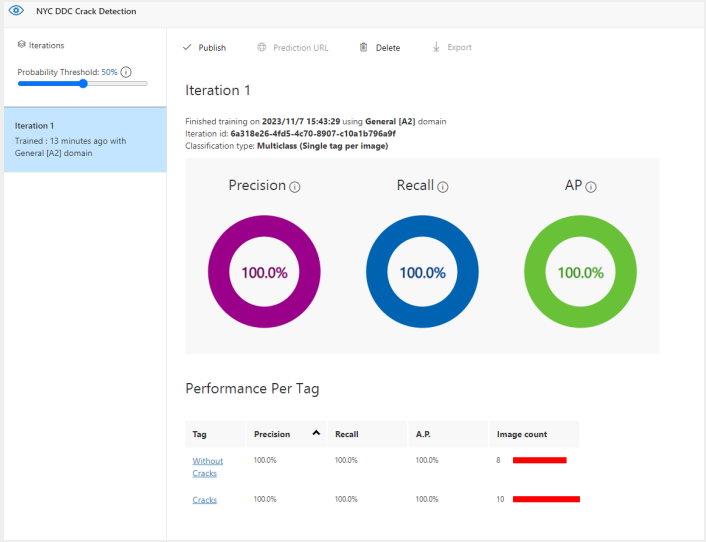


Crack Detection:

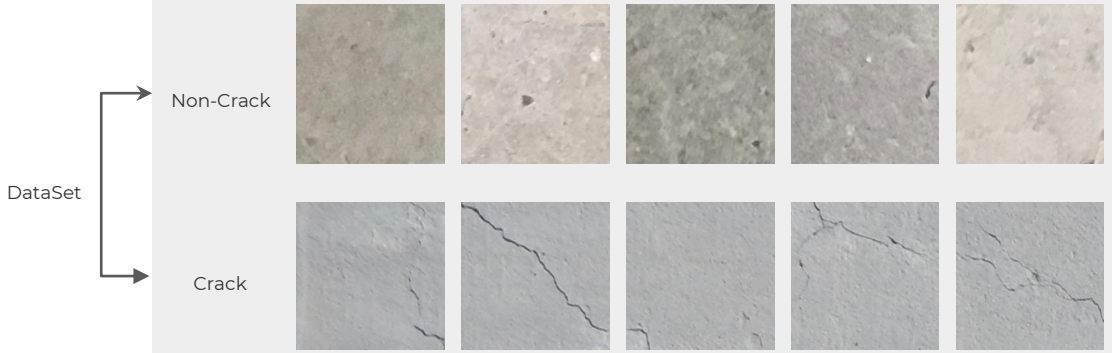
Image Processing and Machine Learning

Steps:

1. Upload images that contain cracks as well as images that do not have cracks.
2. Label each image to indicate which images contain cracks.
3. Once you have uploaded and labeled enough images, you can train the model.
4. Click the "Train" button on the Custom Vision website to train your classifier.
5. Once training is complete, evaluate the performance of the model to see metrics such as accuracy and recall.
6. If the performance is poor, you may need to upload more images and retrain the model.



Crack Detection



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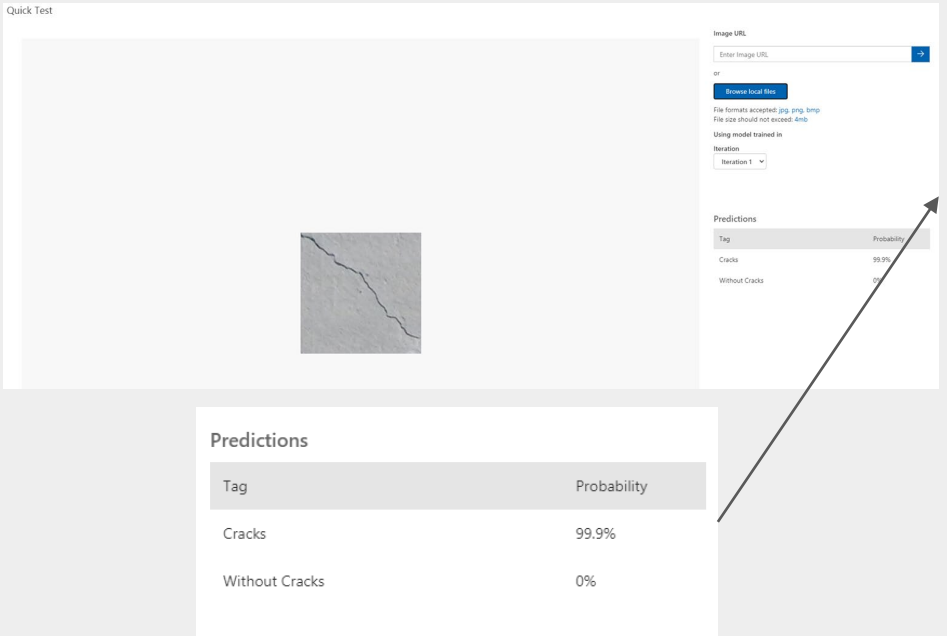

PPE Detection

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First

Correct Equipped with safety helmet, safety glasses, reflective undershirt

Second

Is the machine switched off？

Are flammable and explosive materials in close proximity to the machine？

Third

Whether construction cranes and other equipment are safety or not？

PPE Detection

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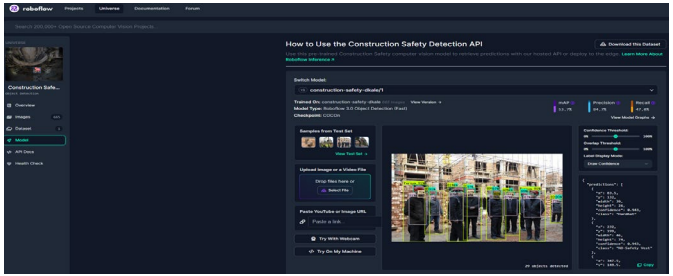
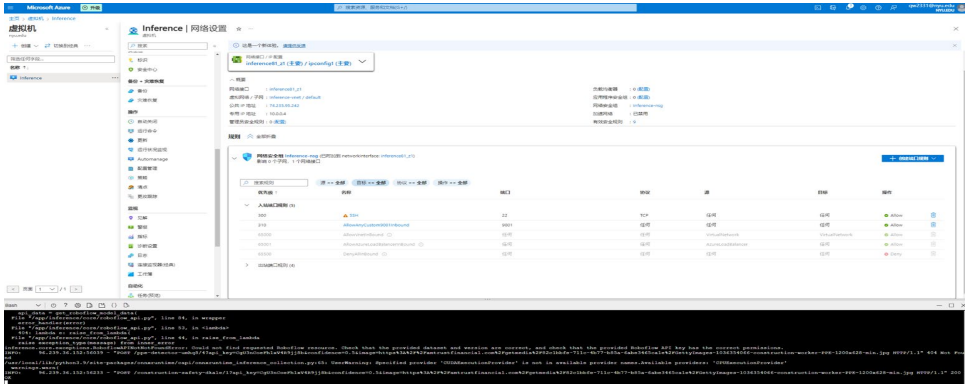
Test Pic



[How to deploy trained model into Azure Virtual Machine]



PPE Detection

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- JSON
  - time : 0.5899432550031634
  - image
    - width : 1200
    - height : 628
  - predictions
    - 0
      - x : 739.5
      - y : 136.5
      - width : 189
      - height : 137
      - confidence : 0.9742802977561951
      - class : "Hardhat"
      - class_id : 2
    - 1
      - x : 754
      - y : 281
      - width : 128
      - height : 74
      - confidence : 0.9598124027252197
      - class : "NO-Mask"
      - class_id : 6
    - 2
      - x : 791.5
      - y : 332
      - width : 537
      - height : 592
      - confidence : 0.8810127377510071
      - class : "Person"
      - class_id : 8

Test Pic

```
C:\Users\VictorWang>python
Python 3.11.6 (tags/v3.11.6:8b6ee5b, Oct  2 2023, 14:57:12) [MSC v.1935 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> import requests
>>>
>>> dataset_id = "construction-safety-dkale"
>>> version_id = "1"
>>> image_url = "https://amtrustfinancial.com/getmedia/82c1bbfe-711c-4b77-b85a-6abe3465ca1e/GettyImages-1036354066-construction-worker-PPE-1200x628-min.jpg"
>>>
>>> api_key = "CgU3nCoeFh1xV4R9jj8b"
>>> confidence = 0.5
>>>
>>> url = f"http://74.235.95.242:9001/{dataset_id}/{version_id}"
>>>
>>> params = {
...     "api_key": api_key,
...     "confidence": confidence,
...     "image": image_url,
... }
>>>
>>> res = requests.post(url, params=params)
>>>
>>> print(res.json())
{'time': 0.5899432550031634, 'image': {'width': 1200, 'height': 628}, 'predictions': [{'x': 739.5, 'y': 136.5, 'width': 189.0, 'height': 137.0, 'confidence': 0.9742802977561951, 'class': 'Hardhat', 'class_id': 2}, {'x': 754.0, 'y': 281.0, 'width': 128.0, 'height': 74.0, 'confidence': 0.9598124027252197, 'class': 'NO-Mask', 'class_id': 6}, {'x': 791.5, 'y': 332.0, 'width': 537.0, 'height': 592.0, 'confidence': 0.8810127377510071, 'class': 'Person', 'class_id': 8}]}
```

Code

Results to Json

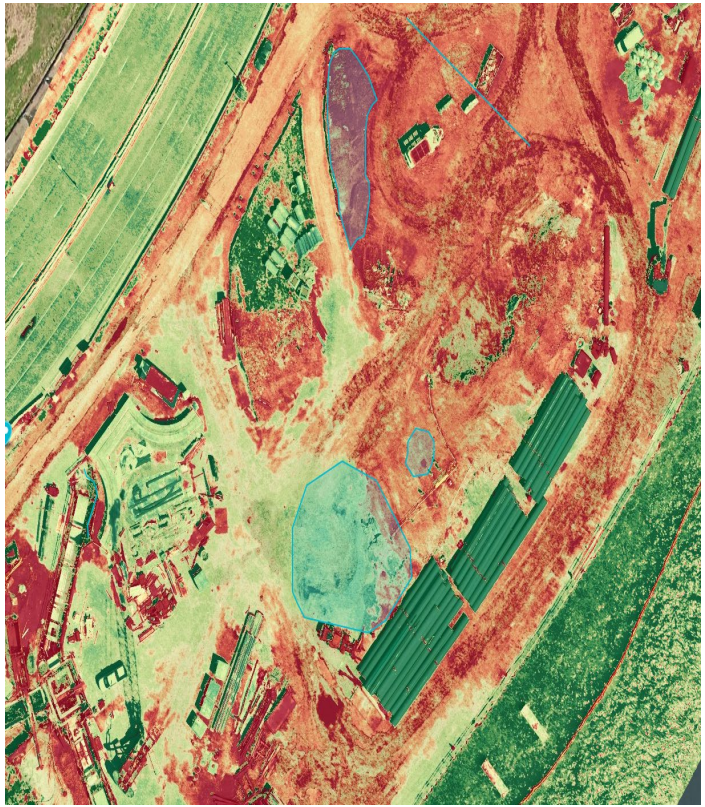
Drones

Advancing Construction Monitoring through Aerial Insights

-Site Surveying and Mapping: Useful for surveying construction sites by providing detailed aerial views. They can create topographic maps, identify issues, and plan site logistics.

-Progress Monitoring: Capture images of construction sites and compare them to BIM models to monitor progress and identify any deviations from the plans.

-Inspection and Quality Control: Inspections of high-rise structures, eliminating the need for scaffolding or cranes. The captured images and videos can be analyzed to ensure construction quality meets standards.



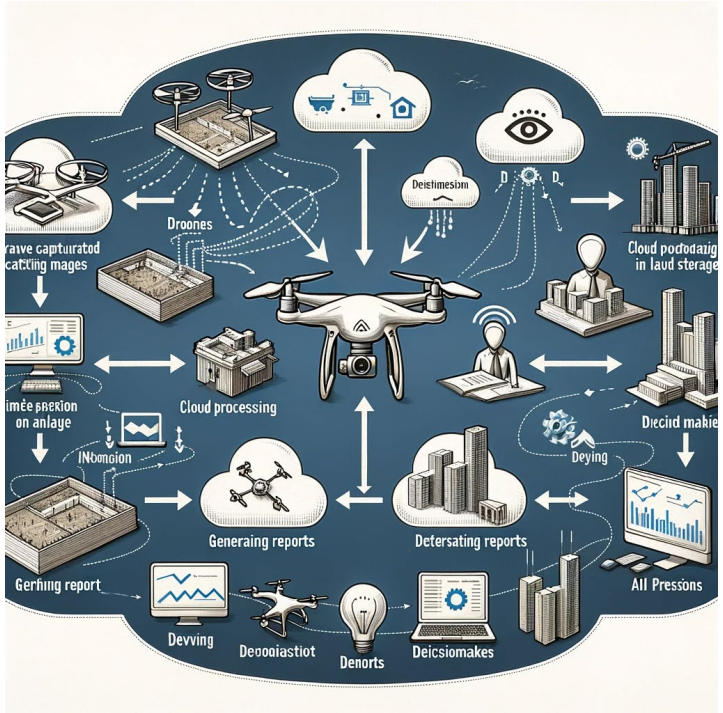
Drones

From Air to Analysis: Utilizing Drone Data

-Integration with BIM Software: Integrate with BIM software, providing a 3D model that overlays real-time data from the construction site.

-Communication and Collaboration: Drones and BIM integration provide a visual representation of projects, improving communication and collaboration between stakeholders.

- Asset Management and Documentation: Drones can be used during construction to document the site, which is useful for future reference, maintenance planning, and legal purposes.



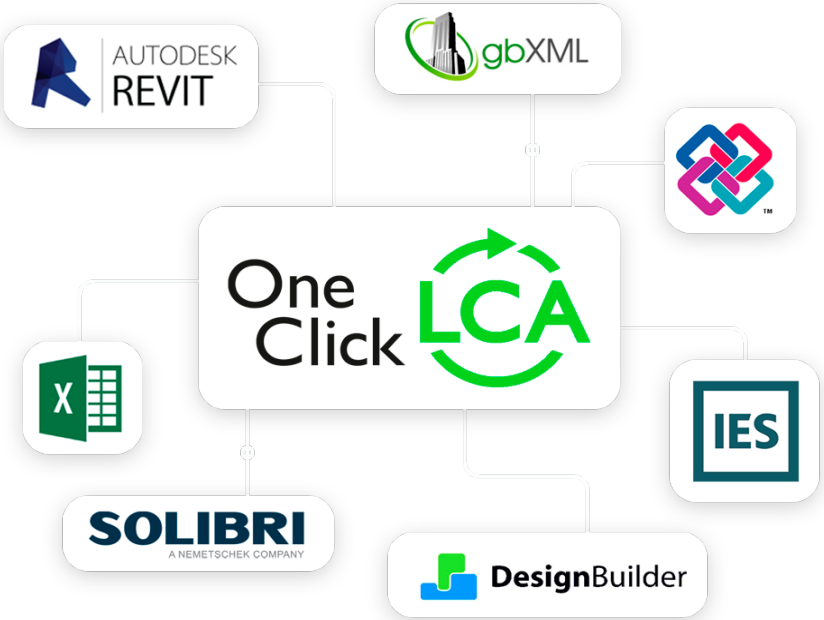
Section II - Potential Use of Images in BIM Setting

- What is BIM
- Importance of Images Taken Before, During, and After the completion of a project in BIM
- Roadmap to Add images in BIM Across Project Phases

PART 1
What is BIM

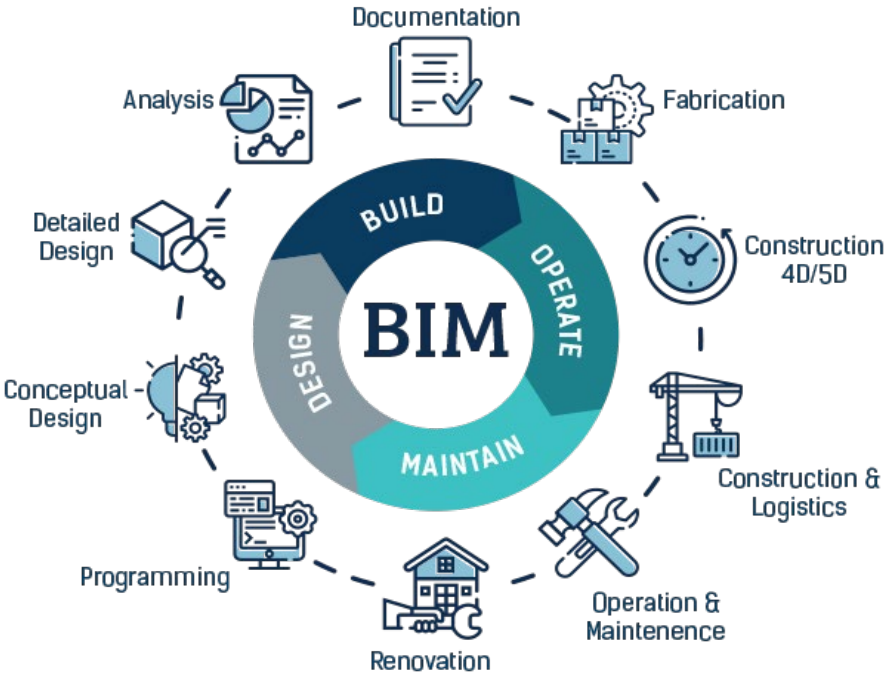
Building Information Modeling (BIM)

BIM is a process that involves the creation and management of digital models of a facility's physical and functional characteristics. These models can be used for design, construction, and operation throughout the entire lifecycle of a structure.



BIM in Construction Projects

Building Information Modeling (BIM) is a transformative technology and process in the construction industry that involves creating and using intelligent 3D models to inform and communicate project decisions. BIM goes beyond traditional 2D drawings, allowing stakeholders to collaborate, visualize, and analyze various aspects of a construction project throughout its lifecycle.



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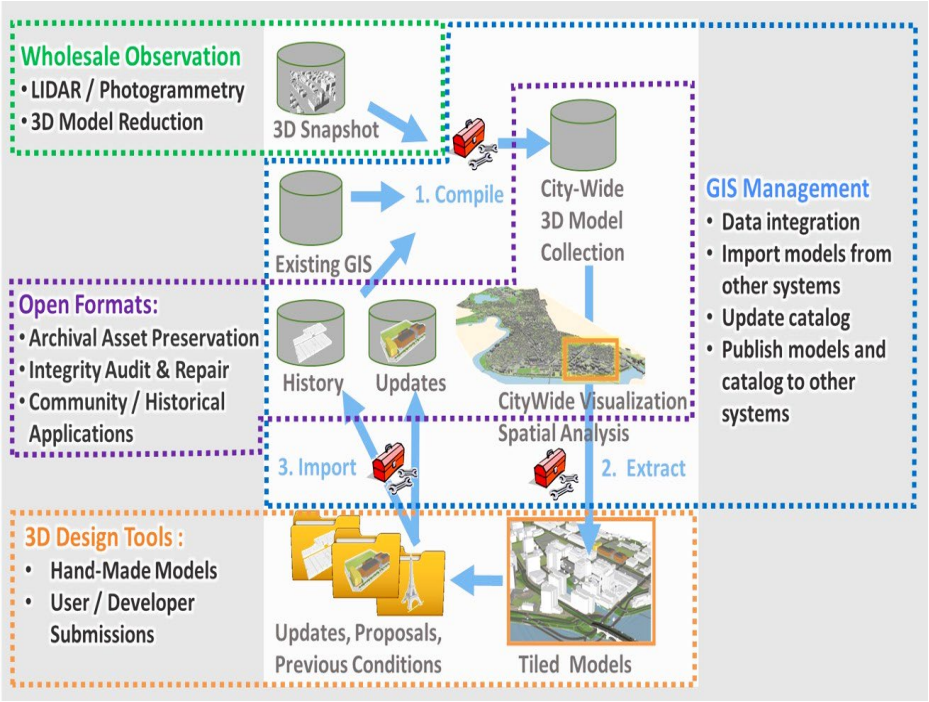
Key Components of BIM

BIM can be used for various purposes during the lifecycle of a project

3D Modeling	Data Modeling
Data Integration	Interoperability
Collaboration	Analysis and Simulation



Part 2
Importance of Images Taken Before, During, and After the completion of a project in BIM

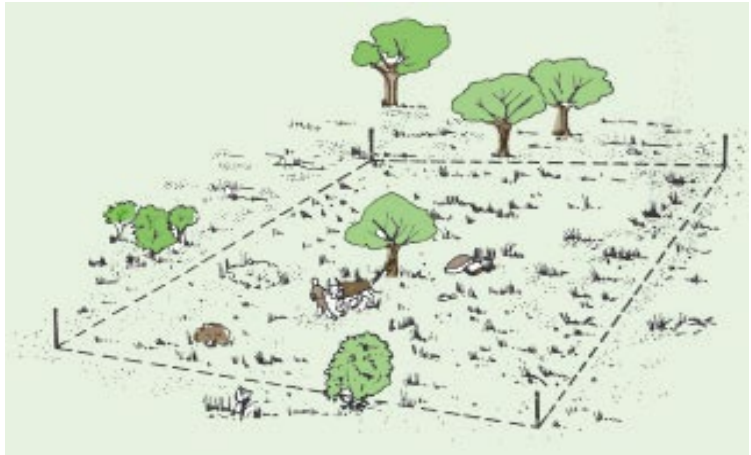
Before Construction:

Site Analysis and Planning:

- Images taken before construction can help document the initial state of the site, providing valuable information for site analysis and planning.
- Identify existing structures, topography, vegetation, and any potential challenges or constraints.

Pre-Construction Documentation:

- Establish a baseline for existing conditions, aiding in pre-construction documentation.
- Useful for regulatory compliance and historical reference.



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During Construction:

Progress Monitoring:

- Regularly captured images during construction provide a visual timeline of the project's progress.

Issue Identification:

- Images can be used to document and communicate issues or challenges encountered during construction.

Quality Control:

- Photographs can serve as a quality control tool, helping to identify deviations from plans or specifications.

Safety Documentation:

- Capture images to document safety protocols, potential hazards, and adherence to safety regulations.
- Useful for training purposes, compliance, and post-incident analysis.

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Post Completion:

As-Built Documentation:

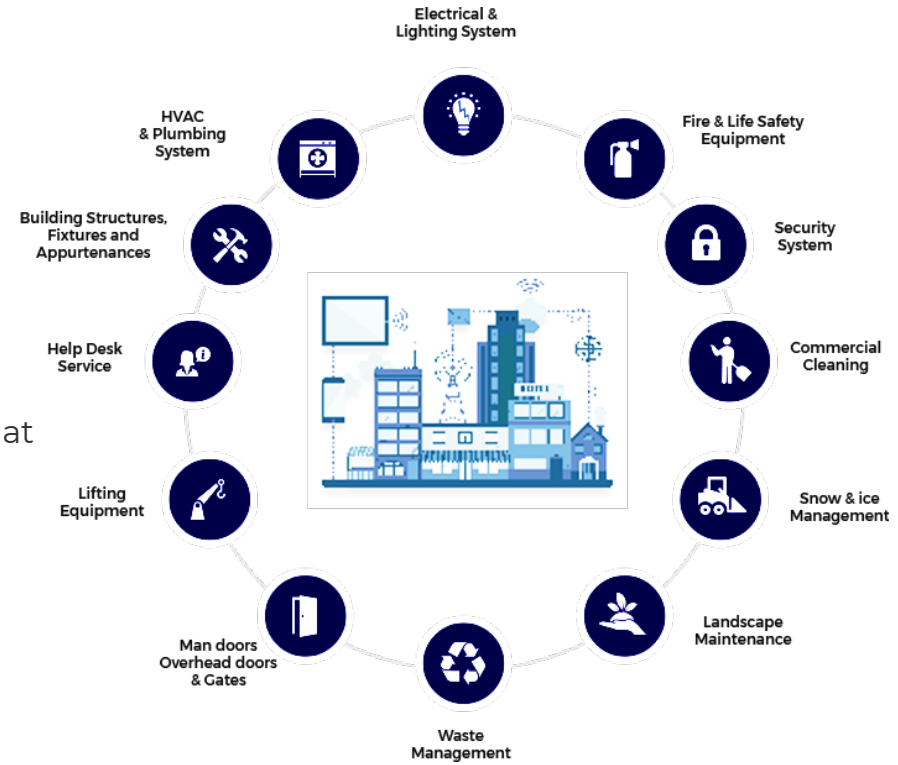
- Post-construction images can be used to create accurate as-built documentation including any modifications or deviations from the original plans.

Facility Management:

- Images assist facility managers in understanding the building's layout, systems, and condition after completion.
- Useful for maintenance planning, identifying areas that may need attention, and guiding future renovations.

Historical Record:

- As time passes, post-construction images become a historical record of the project's evolution.
- Useful for reference in case of future renovations, expansions.



Part 3
Roadmap to Add images in BIM Across Project Phases

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Select BIM Software

- Choose a BIM software that supports visual integration and is widely accepted in the industry.
- Ensure compatibility with collaborative features for multi-disciplinary use.

Create a BIM Execution Plan (BEP

- Develop a BIM Execution Plan outlining how BIM will be implemented throughout the project.
- Specify standards, protocols, and workflows for adding pictures.

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Design Phase:

Model Development:

- Develop a detailed BIM model capturing architectural, structural, and MEP elements.

Conceptual Visualization:

- Integrate concept sketches and preliminary design images.
- Attach images to relevant elements to convey design intent.

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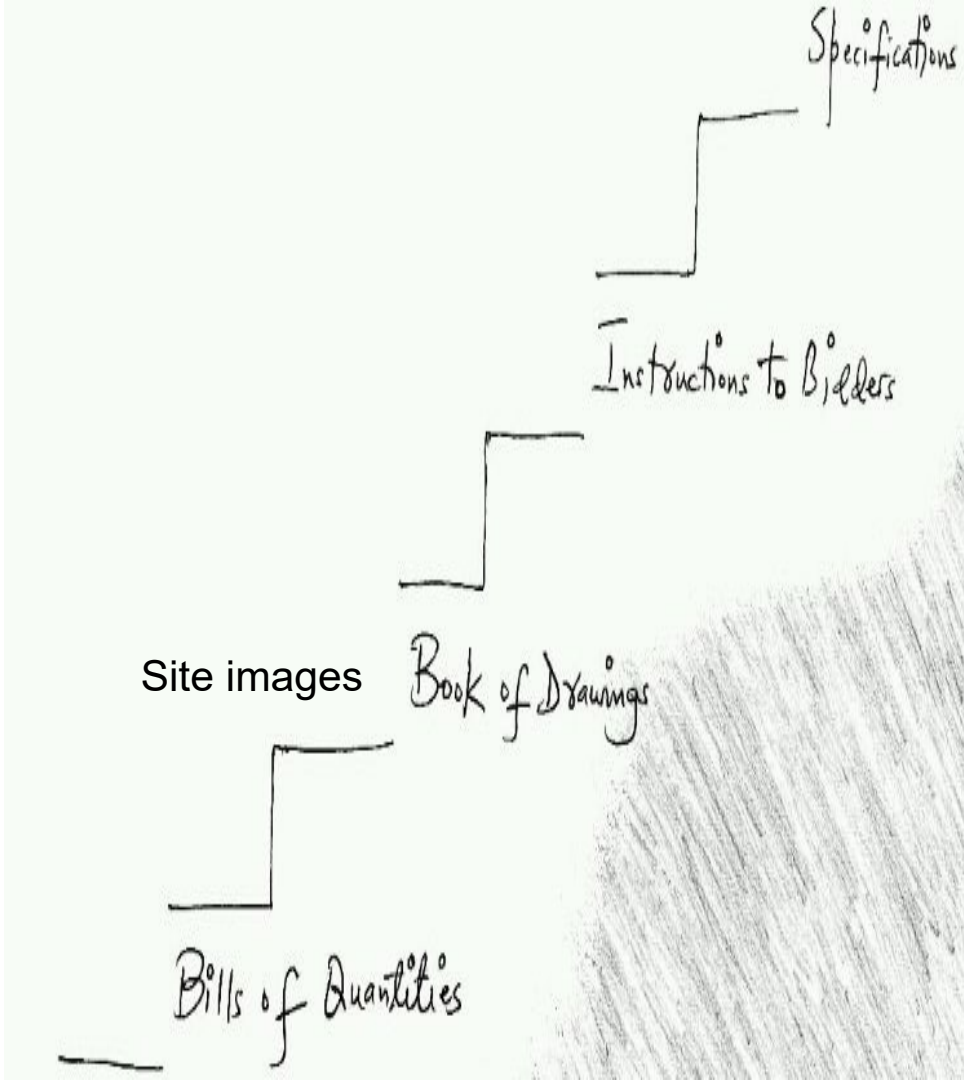
Bid Phase:

Visual Context for Bidders:

- Add images providing context about the project site, surroundings, and neighboring structures.
- Visualize construction methodologies and logistics for better bidder understanding



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Construction Phase

- **Construction Progress:**
  - Incorporate construction progress photos, site images, and documentation.
  - Attach images to construction elements like walls, columns, or site components.
- **Logistical Considerations:**
  - Add images showing logistical considerations, storage areas, laydown yards, and staging zones.
  - Provide visual references for construction planning.

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Post-Completion Phase:

As-Built Documentation

- Integrate images documenting as-built conditions.
- Attach pictures to elements reflecting the final state of the project.

Maintenance Visuals

- Add images related to equipment, maintenance procedures, and facility management.
- Attach images to elements requiring ongoing maintenance.

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Part 4

Occupancy & Use

Occupancy & Use

BIM models in the occupancy and use phase offer a comprehensive, dynamic, and interactive repository of information about the building. This information is invaluable for efficient facility management, proactive maintenance, lifecycle assessment, and long-term sustainability of the building. The integration of BIM with emerging technologies like IoT, AI, and smart building solutions further amplifies its utility in this phase.

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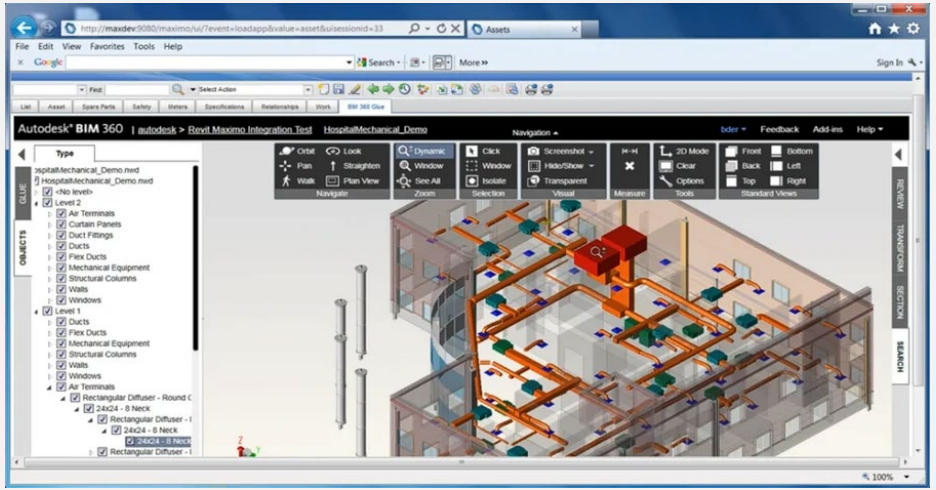
Facility Management

Space Management and Optimization: BIM models provide detailed information on spatial layouts. This can be used for efficient space management, planning interior layouts, or reconfiguring spaces as per changing needs.

Asset Management: BIM integrates detailed data about every component of the building, including fixtures, furniture, and equipment. This data can be used for effective asset management, inventory control, and planning for replacements or upgrades.



The integration of BIM with systems like **IBM Maximo** transforms traditional asset and space management into a more dynamic, data-rich, and visually oriented process. It enables facility managers to make more informed decisions, optimize the use of resources, and enhance the overall operational efficiency of the facility.

Source:https://www.bpdzenith.com/the-bpd-blog/maximo-and-bim

Maintenance Scheduling

Accruent's vx Maintain, *when integrated with Building Information Modeling (BIM), can significantly enhance maintenance scheduling, including preventive and predictive maintenance*

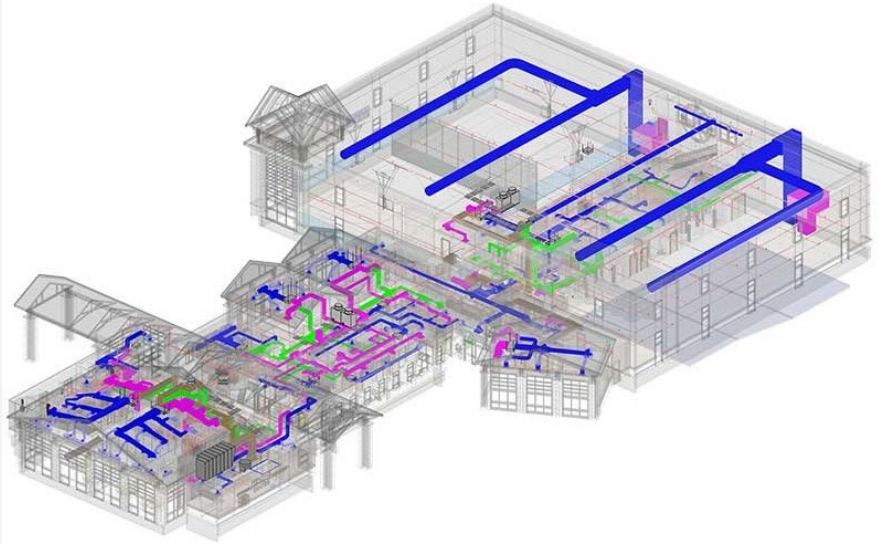
Preventive Maintenance Planning: The integration allows vx Maintain to access detailed BIM data, enabling it to schedule regular maintenance activities based on the specific needs and lifecycle data of building components, ensuring timely upkeep and reducing downtime.

Predictive Maintenance: By combining BIM's detailed structural and asset information with real-time operational data in vx Maintain, the system can predict potential maintenance issues before they occur, allowing for proactive repairs and optimizations.

Building Lifecycle Management

Energy Analysis and Sustainability: BIM models can be used for ongoing energy analysis, helping to identify areas where energy usage can be optimized for sustainability. This includes analyzing HVAC system performance, lighting efficiency, and other energy-intensive systems.

Renovation and Retrofit Planning: For future renovations or retrofits, BIM models provide a comprehensive understanding of the existing conditions. This aids in planning, estimating, and executing renovation projects more effectively.



Source:https://www.united-bim.com/mechanical-hvac-modeling/

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Level of Detail (LOD)

Level of Detail (LOD) is a concept widely used in Building Information Modeling (BIM) to specify the amount of detail and accuracy contained in a model. It helps in managing the complexity of BIM models and optimizing performance. When it comes to incorporating images, LOD strategies become essential to ensure that the model's performance is not compromised by the inclusion of large image files. LOD is often categorized into different levels, with LOD 400 and LOD 500 being specific levels related to geometry and information.

Application of Images in LOD

LOD 400 (Geometric Detail):

- LOD 400 is a level of detail where the BIM model includes specific and accurate geometric details of building components. It is associated with fabrication and construction-level detailing.

- Application to Images: In the context of images, LOD 400 would mean that high-resolution images are loaded and displayed when a detailed view of a specific area is required. For example, in a construction project, you might only load detailed images for elements that are being actively worked on or reviewed.

LOD 500 (As-Built)

- LOD 500 represents the highest level of detail, where the BIM model includes as-built information. It reflects the exact size, shape, location, quantity, and orientation of all elements in the model.

- Application to Images: For images, LOD 500 implies loading high-resolution images when as-built, final documentation or facility management view is required. This could include photographs of the completed construction, as well as detailed images for maintenance or renovation purposes.

Key Considerations for Using Images in BIM

Standardize Image Formats: Define standards for image file types, resolutions, and naming conventions. Ensure consistency across all project phases.

Collaboration and Communication: Effective communication among stakeholders is facilitated by sharing images within the BIM environment. This ensures that all parties have a clear understanding of the project's status and potential impacts on cost and schedule.

Change Management: Images play a crucial role in change management, allowing project teams to document and assess changes, both in terms of cost implications and schedule adjustments.

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Thank You

Innovating for Better Future

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