Valuable Visuals:

The power of digital-driven image analytics

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Executive Summary

Images can be found everywhere in today's world, presenting a massive opportunity to capitalize on their untapped value.

While nobody can say for sure exactly how many images exist, some estimates suggest that around 3 billion images are shared on the internet every single day, with billions more being produced and stored offline on cell phones, digital cameras, computers, and data centers for both personal and commercial reasons.

Each and every image file is comprised of thousands of pixels, equating to a significant amount of data overall. With today's machine learning (ML) and artificial intelligence (AI) technologies, businesses are able to extract immense value from this data by discovering new patterns and hidden information in the pixels. Against this backdrop, the scope of image analytics-driven solutions and go-to-market products is immense. From retail analytics that recognize consumers' emotions to forensic scene reconstruction in law enforcement, the potential is limitless.

The medical industry is particularly well-suited to the benefits of image analysis tools. Deep learning models such as convolutional neural networks (CNN) can assess many thousands, if not millions, of diagnostic images in a very short space of time, building a benchmark database for future patients. When new images are introduced, the technology can quickly recognize patterns and provide doctors with a rapid, accurate hypothesis on the patient's condition.

To communicate how image analytics can enhance the value of medical diagnostic imaging, this white paper explores the techniques that businesses can use to introduce analysis technologies into their organization, along with the challenges involved in the process. Readers can expect to learn about the global image analytics market and the potential for market penetration, as well as how HGS Digital is carving its own niche in the segment worldwide.

Introduction to Image Analytics

Image analytics is a method of extracting actionable intelligence and meaningful information from digital images, such as photographs, scanned files, bar codes, medico-diagnostic images, or simple screenshots taken on cell phones and computers.

The process incorporates multiple techniques from digital image processing and stochastic image processing to make images clean, usable and readable. This enables the assessment of patterns and objects in the image and how they are associated with each other, combined with their relative significance in the context of the scene, resulting in clear information on what the image contains.

In the context of clinical diagnosis and biomedicine, the success of a radiologist or a doctor is not measured by how many images they can analyze, but how well they can decipher the information contained within. This concept is the same for image analytics software, which can act as a "third eye" to study and learn from the images, supplementing the knowledge of doctors and radiologists to empower them to make faster and more accurate diagnoses.

What is image analytics

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Global Image Analytics Market

Research suggests staggering projected growth for the advanced analytics industry

Computer Vision Market

US$17.4 billion/2023

Markets and Markets' global computer vision market forecast predicts the sector to be worth US$17.4 billion by 2023.

Medical Image Analysis

US$4.51 billion/2024

A report from Grand View Research suggests that the medical image analysis software market will be worth US$4.51 billion by 2024.

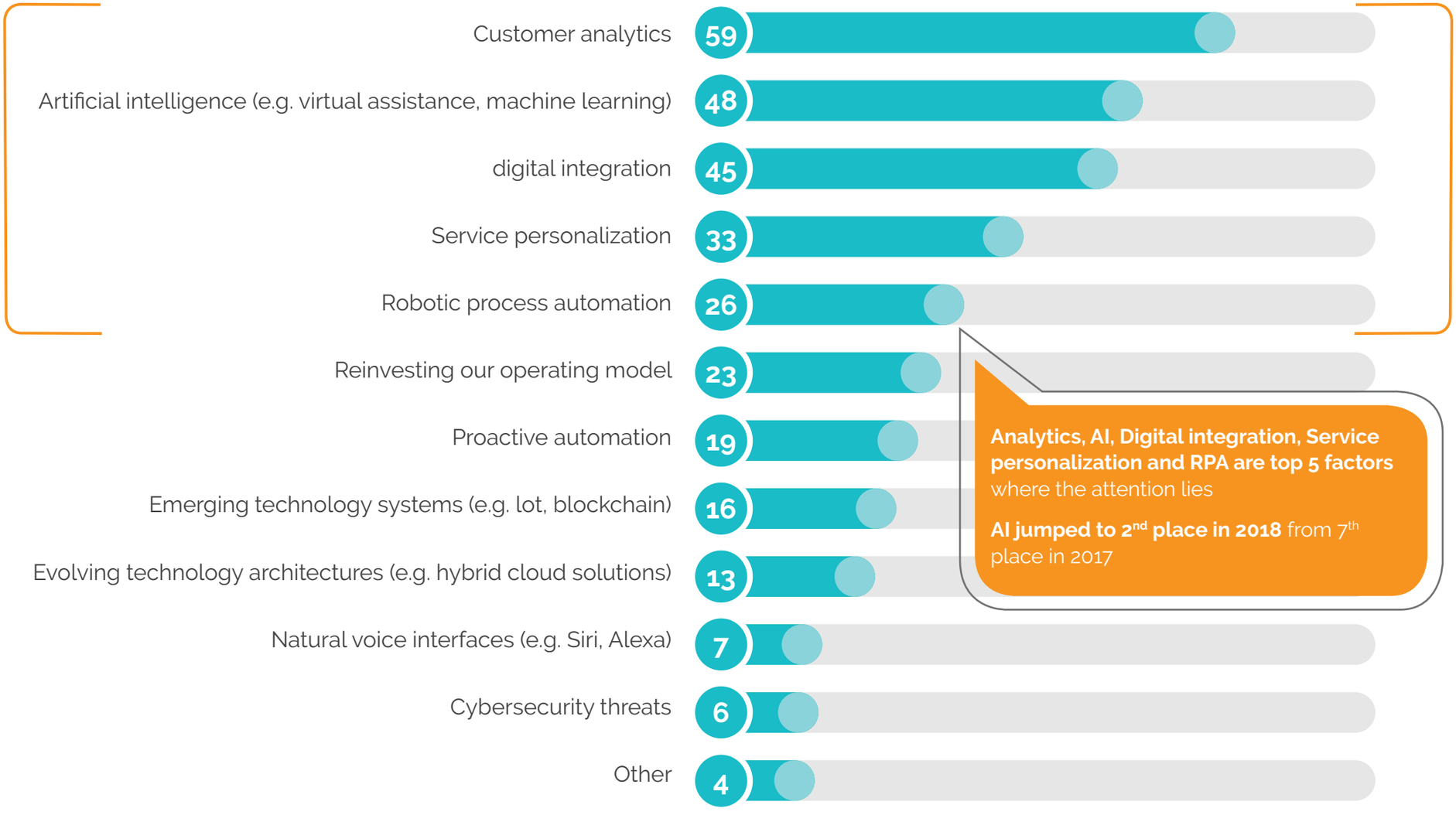
Artificial Intelligence

US$15.17 trillion/2030

PwC estimates that the potential contribution of artificial intelligence (AI) to the global economy will be US$15.17 trillion by 2030.

CX Analytics trends - CX Transformation

Analytics seen as top factor to reshape cx industry



Graph Source: 2019 Global Customer Experience Benchmarking Report, Dimension Data

CX Analytics trends - Technology enablement

Analytics - a top technology trend

Technology trend	Rank 2016	2017	2018
Analytics	4	3	1
Self-service (Incl. web, mobile, IVR)	Not asked	Not asked	2
Omnichannel - Integration of technologies	1	1	3
Digital business transformation	3	2	4
Aertificial intelligence (Incl. virtual assistants, machine learning)	Not asked	Not asked	5
Robotic process automation	Not asked	Not asked	6
Cloud solutions	7	4	7
Personalization of services	Not asked	5	8
Emerging contact channels (e.g. WhatsApp, IMessage)	Not asked	Not asked	9
Cybersecurity (Preventing attacks and fraud prevention)	6	10	10
Technology consolidation	2	8	11
Biometrics (facial, voice, fingerprint, etc.)	10	13	12
Proactive automation	9	9	13
Internet of Things	Not asked	12	14
Other	9	11	15
Blockchain technologies	Not asked	Not asked	16

Analytics is now the top technology trend being prioritized by CX teams

AI has emerged as one of the top five trends

Graph Source: 2019 Global Customer Experience Benchmarking Report, Dimension Data

Which companies are seeking to provide public service through imaging?

- Google: Self-driving cars - USA
- Sensetime: Facial recognition to track citizens - China
- Facebook: USA
- DJI: Drones and Autonomous vehicles - China
- Banjo: Search social media to identify real-time events critical for emergency services
- Ceres Imaging: California-based provider of aerial imagery for farmers and agriculture companies. The images provide unmatched plant-level detail that enables growers to optimize water and nitrogen use, increasing yields and saving time and money - USA
- Arterys: Medical imaging viewer along with lung and cardio information using Deep Learning - Israel
- Zebra Medical Vision: Accessible AI for radiology that harnesses a complete dictionary of normal and abnormal findings that are automatically detected and analyzed - Israel

Who are the experts in the Image Analytics space?

- Yann le Cun: Image Recognition (CNN and its application to optical character recognition (OCR))
- Geoffrey Hinton: Image recognition
- Dag Kittlaus: Siri (Automated voice assistant)
- Demis Hassabis: Deep Mind and Alpha go
- Andrew Karpath: Director of AI (Tesla)

Key Benefits of Image Analytics

The development and deployment of an image analytics platform are connected to numerous benefits, with improved processing times, high diagnostic accuracy, and diagnostic forecasting being the most impactful.

When used to its full potential, image analytics software allows doctors to better serve patients and reduces the loss of credibility associated with incorrect diagnoses. It can result in lower costs, fewer issues with overpayments, faster recovery times, and much higher levels of positive customer experience. Moreover, it can boost collaboration and information sharing between radiologists, doctors, and data scientists, leading to further benefits on the customer side.

Health insurance companies are equally poised to benefit from image analytics. AI-powered image recognition platforms can process scans to quickly produce rich insights into a patient's condition. This information enables insurers to more accurately assess customer risk and determine the best pricing models. As insurers and doctors start to combine these automated insights there will be numerous opportunities to enhance the entire industry.

Key benefits of image analytics platforms:

- ✔ Improved processing times
- ✔ High diagnostic accuracy
- ✔ Diagnostic forecasting

Applications of an Image Analytics Platform

Image analytics software can encompass a number of components that serve many different functions.

- Image data, metadata, and geodata extraction
- Image pre-processing
- Signal and Stochastic processing
- Image works
- Image editing, segmentation, filtering, transformation, restoration, and image enhancement
- Image analysis: pattern recognition and edge detection
- Image exploitation: feature selection, feature extraction, clustering and classification
- Picture processing: developing the capability to read scanned images and extract information

- Email processing: extract attachments, subject line, and related metadata

- Text processing and natural language processing (NLP): extract and interpret special characters including symbols, emojis, icons, shapes, grammar points, and other graphical content

- Geometric analysis of images: Involves the use of tessellation, triangulation (distances), Voronoi diagrams, translations (rotations and movements), and trilateration (angles) in facial recognition and object reconstruction.

Companies that are actively performing R&D in this space are working on several cutting-edge technologies in various emerging areas of applications. Some of the top use cases include:

- Autonomous cars: Object Identification
- Image analytics to speed up airport traffic
- Analyzing social media for missing persons
- Real-time vehicle damage assessment
- Security, surveillance and intrusion detection
- Image analysis: pattern recognition and edge detection
- Provide a second opinion to the doctors: Medical imaging (Advanced in case of MRI)
- Agritech: Identifying crops, water scarcity, etc.

Getting Started with Image Analytics

Organizations should view image analytics as an emerging ecosystem rather than a trending buzzword. With business-oriented planning and careful nurturing, it can become a self-sustaining aspect of the company that drives all-around growth.

Once the decision has been made to explore image analytics as a viable enhancement to the organization, there are certain factors to consider, like implementation timeframe, cost, and potential market penetration.

Off-the-Shelf or In-House?

The problems associated with commercial off-the-shelf and third-party image analytics solutions are manifold.

Primarily, suppliers are reluctant to share models governed under their IP, which are comprised of pre-trained models or libraries that are generally not open to tweaks or customizations. There can also be constraints related to computational ability, costs, data sharing, storage capacity, access control, and Big Data readiness, while some platforms may be completely unsuitable for the needs of medico-diagnostic professionals. Furthermore, commercial off-the-shelf products may not possess the capacity to uncover the exact information related to a company's business objectives, essentially rendering them worthless in the long run.

For organizations that require more control over their image analysis platform, it is recommended to develop a proprietary in-house solution that negates these issues and allows the business to achieve its long-term goals. While the associated costs of software development can be higher in the short-term, the bottom-line value is greatly multiplied over time.

Preparing the Organization

The starting point for all organizations should be to create a tech-savvy, data-driven culture, with processes in place to leverage the wealth of new information that will emerge from image analytics. There needs to be resources for training, cross-skilling, and up-skilling through vigorous quantifiable programs with measurable outcomes.

Within this challenging work culture, teams are encouraged to solve problems, brainstorm, ideate and push themselves further. At HGS Digital we have observed that the data science team, in particular, is highly self-motivated, performing at its peak when confronted with obstacles and obstructions in statistical modeling.

It is also advisable to ground business objectives and evaluate market positioning, as any successful image analytics initiative is directly linked to the organization's goals. A thorough gap analysis will reveal segments and sub-segments where companies can make their mark on the image analytics world.

Implementation Timeline

The adoption of image analytics requires a gestation period of around six months, mainly to set up, upskill, and groom a team of dedicated and well-trained data scientists. A minimum follow-on period of six months is required to set up business objectives, processes, source data, and develop a trainable platform.

Platform Usability

To align with industry standards, image analytics solutions should be designed with a focus on performance and exceptional user experience. They require high computational speeds to process images and to export elaborate data sets with accurate labeling. Prioritizing the quality of the front-end user interface is equally important and will maximize the efficiency of human interactions.

Image analytics software platforms should be built upon a dedicated internal server or a cloud-based infrastructure that allows for periodic maintenance, updates, and feature upgrades. This environment allows for the real-time analysis of outputs and is best suited to addressing security, regulatory, and privacy constraints related to image data. It is highly recommended to avoid a web-portal based design as it can present more challenges in these areas.

Associated Costs and ROI

The biggest challenge for companies, especially those in the start-up space, is the cost associated with these niche technologies. Hiring, retaining and training quality data scientists is especially costly, even when relying upon freely available machine learning tools. Computational requirements usually represent the largest expenditure for businesses, encompassing factors such as software, hardware, data storage, and cybersecurity.

There is also the need to stay up-to-date on recent trends, attend related seminars and conferences, develop cross-functional proficiency in coding languages like R and Python and even help to build a culture of innovation where experimentation is allowed in the workplace. Market outreach, analysis and the process of carving out a niche also remain a challenge for companies who are in it for the long haul, but the eventual rewards are worth the time investment.

Given the right motivations, gap analysis, market positioning and, most importantly, technological upheaval, a company invested in the image analytics space can break even within the first five years, providing they constantly upskill and cross skill to remain at least level with the competition.

Evaluating Image Analytics Vendors

Vendor management is a crucial part of a successful image analytics endeavor, resulting in saved time, lower costs and higher quality software. Vendors that are active in this space can provide pretrained models and APIs and customize them to suit the organization's interests and requirements.

When selecting a vendor, it's important to first understand the company's motivations and objectives in the image analytics space. Ask yourself these questions:

- Why is the company pursuing image analytics?
- What is your business proposition?
- What is your internal capability?
- Where are you facing technological gaps?
- Does your vendor have the credibility to fill in the gaps?
- Does the plug-and-play approach assure seamless project execution?
- What are the IP issues involved?
- What are the data security issues involved?
- What are the computational requirements?
- What are the turnover times?
- What are the costs involved?

Large firms or boutique analytics firms, including start-ups, should focus more on building internal R&D teams to develop their own image analytics IP, keeping external vendor roles to a minimum. Vendor-based project management is more suited to SMEs and mid-cap companies. In these cases, the parent organizations should designate vendors as minimal R&D providers while also being project managers and lead integrators to leverage the maximum amount of knowledge from multiple vendors. This approach enables businesses to build tailor-made solutions for different ventures.

Market Leadership Strategy

Following an incubatory five-year period, companies are encouraged to invest in three or four niche applications to maintain their market leadership in specific areas.

Some of these applications include:

- Facial Recognition – Home and Office: Security, Surveillance, Identification, and Access Control
- Airports – Automated Passenger check-in and Automated Baggage scanning
- Taxis and Railways – Automated Passenger Face Recognition
- Marketing – Using Social Media Images with online activity for tracking and mapping consumer patterns for marketing use: customer segmentation and consumer outreach
- Law Enforcement – Mining Social Media Images for missing persons, cybercrimes and suspect online/physical activity
- Insurance services – Real-time Vehicle Damage Assessment
- Medical Imaging – PET, CT, MRI, US, Mammograms and X-ray scans – Third opinion to augment doctors' diagnosis and radiologists' reports

- Retail – Facial feature and geometric pattern analysis for store visits and footfalls
- BCR/MICR/OCR for product and pricing analytics
- Smart City – Automatic number plate recognition, anomaly detection, and database matching
- Stolen car detection – Detection of license plate numbers, vehicle color, model name and matching information with the database
- Planning – Land-use and land-cover mapping
- Intelligent Transportation Systems – Traffic violations and infractions
- Remote Sensing – Flood plain management, watershed management, resource mobilization, agricultural production monitoring, etc.
- Automatic Visual Inspection System – This application improves the quality and productivity of industrial manufacturing.

The HGS Digital Approach

Given the multitude of image analytics solution providers, it was decided that we at HGS Digital had to create a niche for ourselves in this space, so we invested in a data science R&D program over the space of one year in which we developed in-house models for image processing with a primary focus on applications within facial recognition, medico-diagnostic image mining, and character and object recognition.

During the research phase, we observed that most solutions do not pre-process or clean images before they begin modeling, so we focused on making raw input images readable, trainable, and relatively noise-free. These images were then pushed through several statistical exercises involving image enhancement, image segmentation, feature selection, feature extraction, edge detection, clustering, and classification.

The input data sets included all forms of medical imaging but primarily concentrated on the most frequently used and referred to for claim services:

- X-ray scans – chest and bones
- PET scans
- CT scans
- MRI scans
- Angiograms – Cardio and Ophthalmic
- Ultrasound scans – renal, pelvic (abdominal) and thyroid
- Mammograms
- Fundoscopy
- OCT (optical coherence tomography) scans

With the use of hybrid in-house models, including a mixture of image libraries, APIs, and our own systems, we were able to evolve this image analysis solution into a complete product platform.

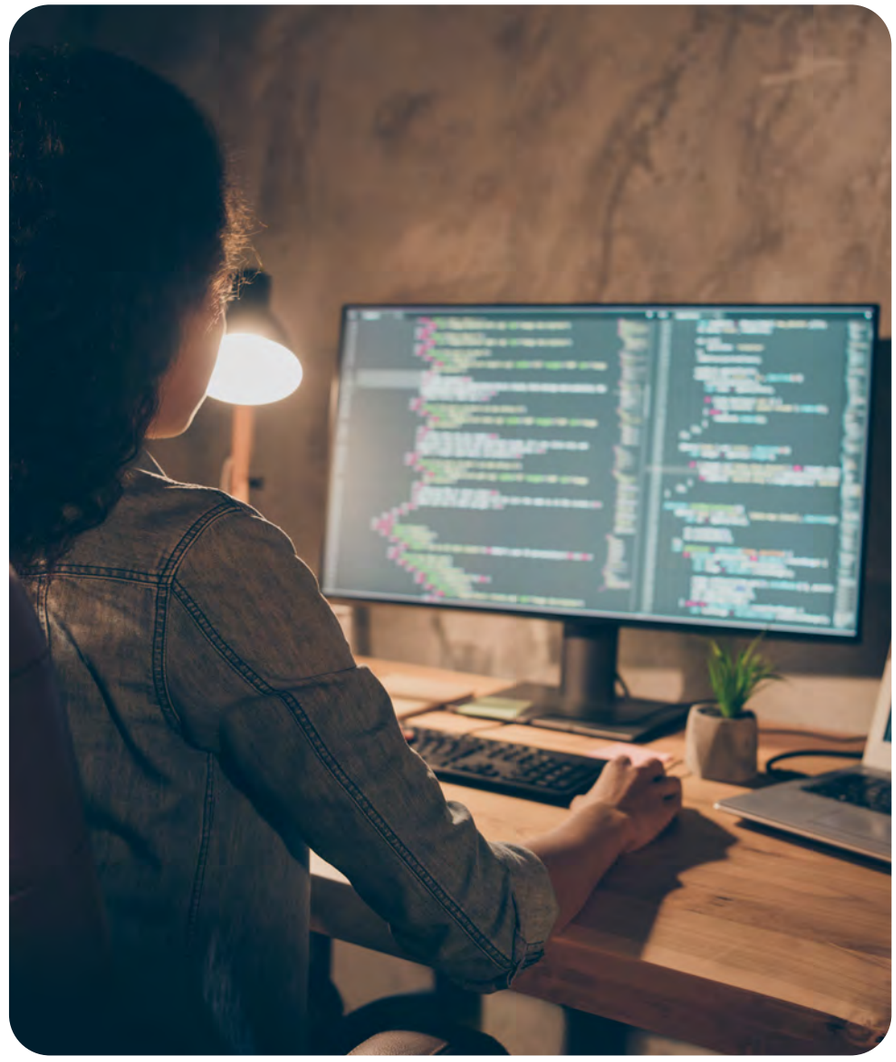
Building a Development Program

When we made the decision to focus on in-house capabilities to complete the project, our research and development program was defined by three pillars: process, technology, and business objectives.

Process

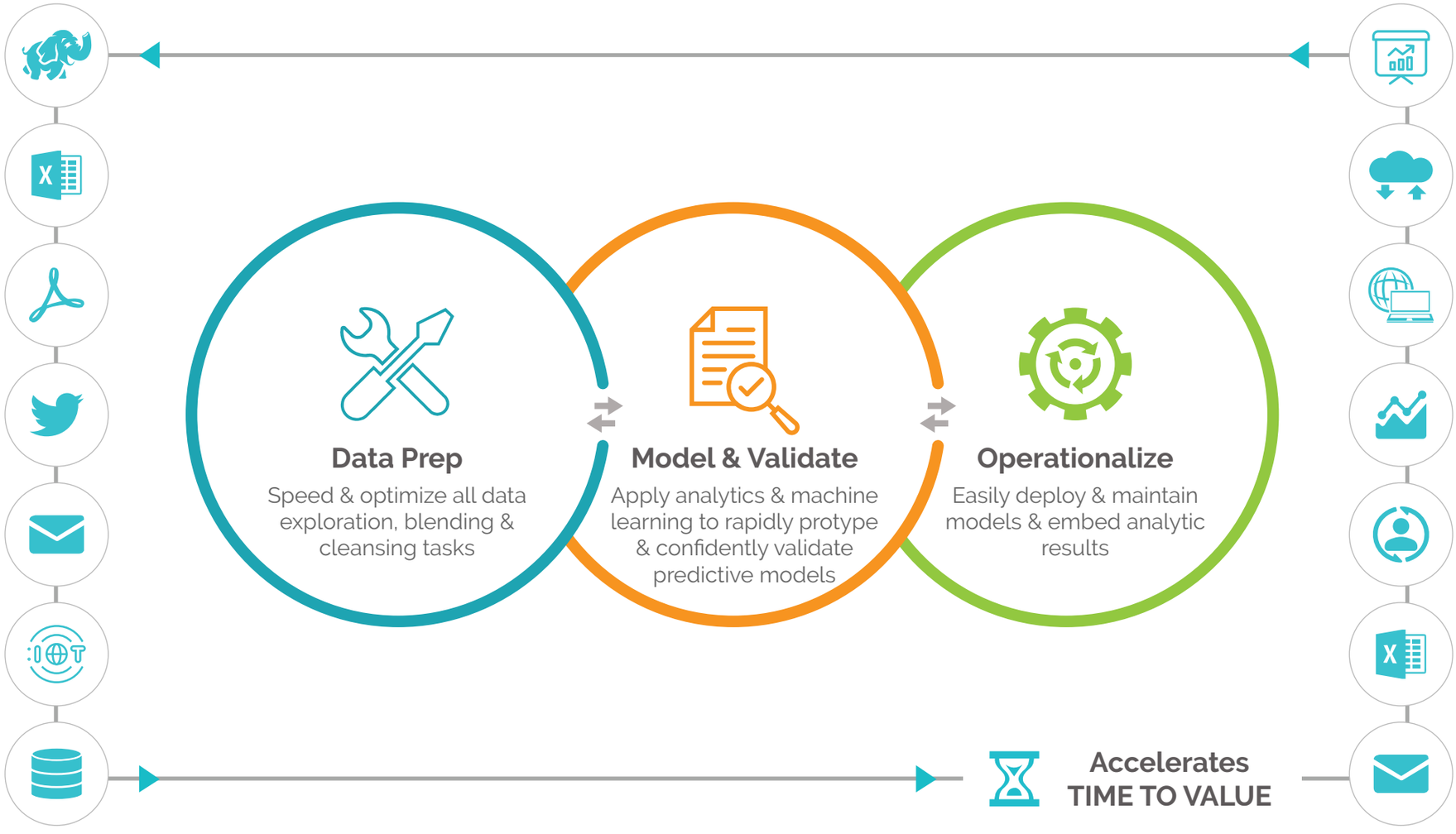
In terms of process, we first set out to define the workflow of the solution, ensuring each component would be a standalone, "feeder" entity that would accelerate time to value.

Images from sources such as Excel, Twitter, Adobe PDFs, emails, and other databases were funneled into a Data Prep component, which optimized the process of data exploration, blending, and cleansing. Once optimized, the images were fed into a Model and Validate component, where analytics and machine learning were applied to rapidly prototype and validate predictive models. These models were then operationalized so they could easily be deployed and maintained, introducing the capacity to export the images and extract metrics and analytics.



It's noteworthy to point out that each component of the image analysis workflow was designed to feed processed images into the others, ensuring that image and data quality was maximized throughout.

Solution Architecture



Technology

To define the right technology for the task, our teams began by studying our available image libraries and APIs, which allowed them to isolate any gaps in the data and identify the tools required for the job.

Another technological consideration was data science, which meant finding experts in data engineering, data sourcing, storage, archiving and pre-processing, data lake creation, and data quality assurance.

On the modeling side, we had to implement tools for model selection, model building, and library development and enrichment. This also included error analysis and model diagnostics, model QA, and IP generation.

Business Objectives

The adoption or development of any image analysis platform requires top-down buy-in from business leaders and should be directly aligned with the company's business objectives.

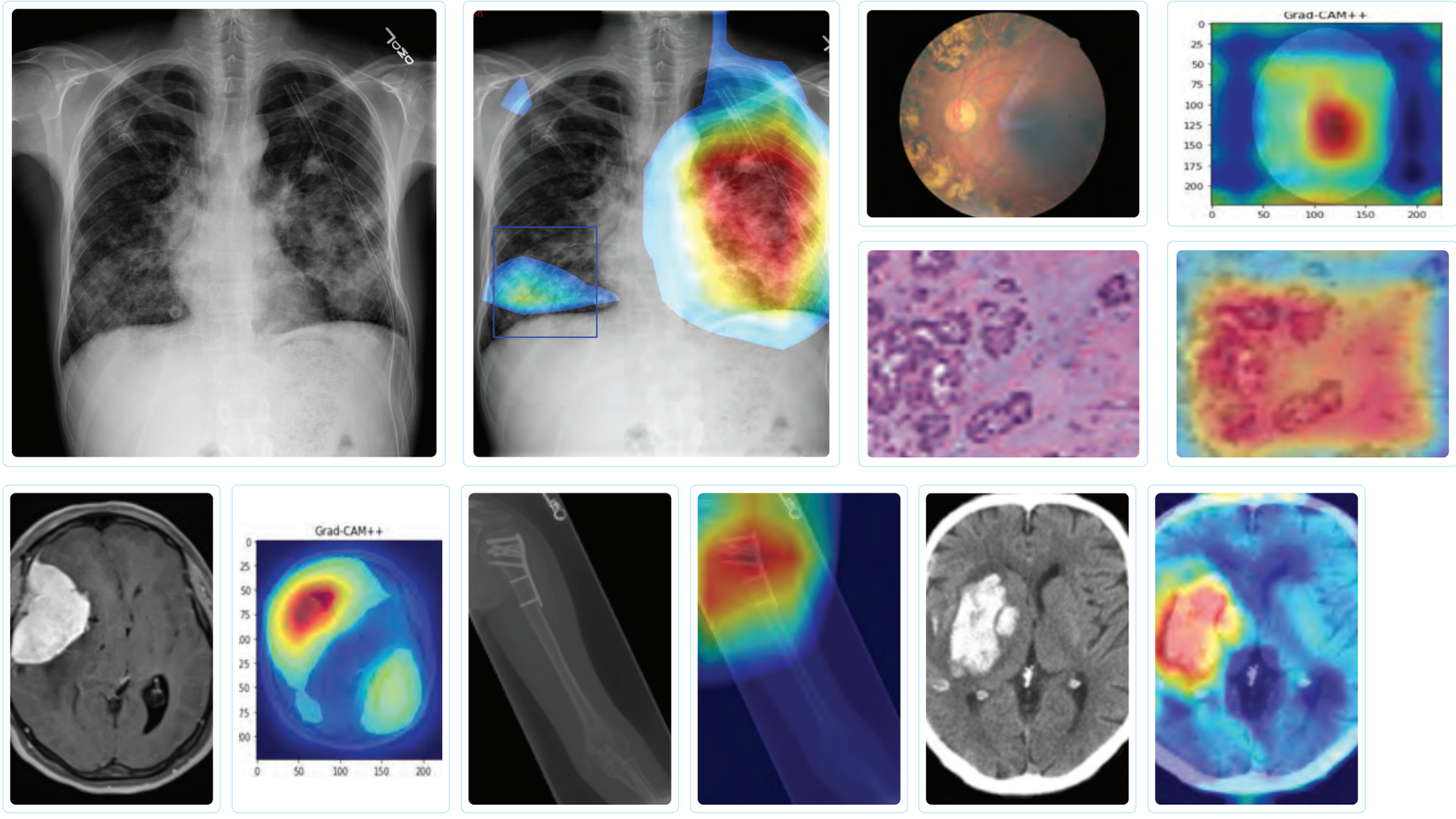
In this HGS Digital case, the company's business objectives were to detect anomalies and provide fast and reliable inputs to doctors and insurance companies during patient diagnosis. This included the detection of secondary or minute abnormalities to ensure no affected areas were overlooked.

The following table details the algorithms that were widely explored to achieve these objectives.

SR. NO	TECHNIQUES	TOOL	METHOD
1	Feature Extraction, Feature Selection	Python	PCA, t-SNE
2	Edge Detection	Python	Canny algorithm
3	Image Classification	Python	Deep Learning - CNN, Transfer Learning
4	Object Classification and Localization	Python	R-CNN (YOLO algorithm)
5	Class Activation Map	Python	Deep Learning - CNN
6	Image Captioning	Python	Deep Learning - LSTM

Results

Following these R&D activities, our solution deployments included providing an array of raw and processed information across a number of bio-medical images. Data mining centered pattern recognition, outlier identification and color-coding of images for quick understanding were visualized as seen in the following outputs:



The way forward – What next for this exercise?

The proposed go-to-market approach is to deploy this solution at leading hospital chains in India using a multi-pronged strategy:

- Employ test hospitals as launch pads for technology acceptance and endorsement.
- Collect UAT reports from them, specifying metrics for business approval and validation, including:
  - Ease of use and user-friendliness
  - Reduction in computational times
  - Reduction in diagnostic times
  - Reduction in claim issues
  - Reduction in diagnostic human errors, etc.
- Vet our findings as being medically reliable in conjunction with radiologists' opinions.

- Vet our findings as being medically reliable in conjunction with radiologists' opinions.

- Source as many labeled images as possible to train and refine our models to improve our accuracy metrics.
  - The labeled data would come from medical experts who have clinically identified the abnormalities.

- Continue analyzing fundamental scans like ultrasounds (renal, abdominal and thyroid), OCTs and angiograms(cardio and ophthalmic).

- Expand our research into advanced bio-medical scans including fluoroscopy to allow for motion capture along with specialty Bone Scintigraphy and DEXA (bone densitometry) scans

- A logical progression would then be a continuing larger-scale study in partnership with medical oversight and review for model ratification.

Why HGS Digital?

HGS Digital is a marketing, data science and technology consulting & services provider that has helped various teams within 100+ organizations with digital transformation and automation solutions. Through our data-driven services, we help customers select the right models and systems and implement a complete strategy that helps teams get higher ROI out of their existing investments.

Our Data Practice has a matured and diverse portfolio, supported by big data experts who help clients successfully strategize and implement data-driven solutions within their organization. By integrating the right data from different systems, we help clients understand their customers better. Through AI- and ML-based data modeling, analysis, reporting and visualization, we are able to provide our clients with timely and highly valuable & actionable insights.

Many large-cap firms and contact center organizations are consciously collecting massive amounts of demographic, transactional, ancillary, and collateral data from across cooperative omnichannels. By investing in a cutting-edge data science and analytics program, HGS Digital is positioned at the forefront of this endeavor, leveraging a diverse portfolio of customized solution development and deployment across multiple industry verticals and domains, including:

INDUSTRY
Media
BFSI
FMCG
CPG
Telecom
Healthcare
Pharma
E-Commerce
Automotive

SOLUTIONS

- HR Analytics
- Retail Analytics
- Marketing Analytics
- Operational Analytics
- Sales Analytics
- Content and Viewership Analytics
- Competition Analytics
- Telecom Analytics
- Social Media Analytics
- Financial Analytics
- Geo Analytics

At HGS Digital, we believe deep learning technologies can extend human abilities beyond traditional pattern matching. By leveraging expertise gained in deep learning, we can offer products and solutions for mining information from digital images, while maintaining high levels of excellence.

With a dedicated team of around 30 individuals, including data scientists, SMEs, data engineers, and research professionals, HGS Digital has been able to build a robust portfolio of end-to-end image processing solutions. Our Data Sciences unit has developed an image mining solution that stands out in this regard with its abilities in:

- Thorough data cleansing and pre-processing in the signal space
- Seamless on-site deployment
- Accurate isolation and labeling of discernible patterns
- Robust anomaly and outlier detections
- User-friendly GUI based controls
- Developing and listing editable, trainable and customizable libraries
- Unhindered access to statistical models driven by in-house designs
- Fine-tuning weights and parameters of various ML libraries based on automatic error minimization
- A comprehensive evaluation of models on 100s of imaging data sets for both facial recognition and bio-medical scans
- Custom hybrid modeling leveraging expertise from transfer learning modules
- Being computational optimized and cost moderate
- Operationally friendly based on feedback received in UAT reports
- Periodic updating and upgrading keeping abreast of the latest advances in ML and AI technologies

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