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UIdataGB: Multi-Class ultrasound images dataset for gallbladder disease detection

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ABSTRACT

Artificial Intelligence (AI) allows computers to self-develop decision-making algorithms through huge data analysis. In medical investigations, using computers to automatically diagnose diseases is a promising area of research that could change healthcare strategies worldwide. However, it can be challenging to reproduce or/and compare various approaches due to the often-limited datasets comprising medical images. Since there is no open access dataset for the Gallbladder (GB) organ, we introduce, in this study, a large dataset that includes 10,692 GB Ultrasound Images (UI) acquired at high resolution from 1,782 individuals. These UI include many disease types related to the GB, and they are organized around nine important anatomical landmarks. The data in this collection can be used to train machine learning (ML) and deep learning (DL) models for computer-aided detection of GB diseases. It can also help academics conduct comparative studies and test out novel techniques for analyzing UI to explore the medical domain of GB diseases. The objective is then to

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help move medical imaging forward so that patients get better treatment.

Specifications Table

Subject	Data science: Applied Machine Learning; Applied Deep Learning.
Specific subject area	Health and Medical sciences: Medical imaging; Gastroenterology.
Data format	Filtered
Type of data	Ultrasound Images
Data collection	All these high-quality UI are the result of cutting-edge technologies, specifically Siemens Acuson X700, Philips Affiniti 70, Philips CX50, and Canon Viamo c100 ultrasound machines. Many specialists like medical staff members and expert doctors contributed to the dataset collection. In a first step, all images were painstakingly classified according to a disease type by medical professionals at Jenin Hospital's Specialized Gastroenterology Center. In a second step, the quality of images was checked by senior specialists.
Data source location	The bulk of the training data was collected over the course of four years from four different medical facilities located in Baghdad, Iraq, which are the City of Medicine Teaching Hospital's Gastroenterology department, Al-Numan Teaching Hospital Specialized Gastroenterology Center and Jenin Hospital.
Data accessibility	Repository name: Gallbladder Diseases Dataset [28] Data identification number: 10.17632/r6h24d2d3y.1 Direct URL to data: https://data.mendeley.com/drafts/r6h24d2d3y
Related research article	Obaid, A.M.; Turki, A.; Bellaaj, H.; Ksantini, M.; AlTaee, A.; Alaerjan, A. Detection of Gallbladder Disease Types Using Deep Learning: An Informative Medical Method. Diagnostics **2023**, 13, 1744. https://doi.org/10.3390/diagnostics13101744

1. Value of the Data

- The dataset is composed of ultrasound images of the GB organ from inside the gastrointestinal tract.
- The dataset includes 9 classes according to anatomical landmarks. Each class represents a GB disease.
- The data provide a valuable resource for creating and developing machine learning (ML) and deep learning (DL) algorithms to diagnose GB diseases and classify GB diseases.
- These data help academics conduct comparative studies and test out novel techniques for analysing UI to explore the medical domain of GB diseases.
- These data help researchers create computer-aided detection systems, which will help advance medical imaging and lead to better patients' treatment.

2. Data Description

2.1. Background

Several diseases, including those affecting the gastrointestinal (GI) tract, can affect the human gut system. More than 20 million Americans are diagnosed with Gallbladder (GB) disease or have gallstones each year [1]. In China, there is a high prevalence of GB diseases; approximately 10 % of the adult populace suffers from them [2]. In addition, 12–15 % of individuals have choledocholithiasis-related gallstones [3]. The gold standards for investigating the GI tract are endoscopic examinations and sonography. During a gastroscopy, we look at the esophagus, the stomach, and the first portion of the small intestine, while we look at the colon and rectum during a colonoscopy. Both tests involve digital high-definition endoscope video inspections of the gastrointestinal system. Compared to endoscopes, sonography is easier, more common, and gets results faster. Endoscopic examinations, on the other hand, are resource-demanding and require expensive equipment and trained staff [4–6].

In disease screening, the ability to find abnormalities, stones, and inflammation is seen as an important quality factor [7]. Nevertheless, different doctors may be able to spot abnormalities in different ways, which could affect a person's chance of getting GB disease or colon cancer [8]. Doctors may also disagree on how to classify and rate the severity of discoveries in ultrasound images (UI). Correct disease grading is crucial because it can affect subsequent therapy and monitoring [9]. For example, in inflammatory bowel diseases (IBD), the type of treatment chosen depends directly on how much inflammation there is. An objective and automated system would therefore be very helpful [10].

In written reports, normal as well as unusual results need to be given and explained. Automatic report writing would help doctors spend less time doing paperwork and more time taking care of patients. The use of minimal standard terminology (MST) [11] in reliable and careful recording may also help improve patients' follow-up and care. For the healthcare system to be more scalable and cost-effective, basic research at the intersection of computer science and medicine needs to go beyond standard medical imaging by combining Artificial Intelligence (AI) techniques, distributed processing, and the analysis and retrieval of multimedia data. Next-generation medical big-data applications are a frontier for innovation, competition, and efficiency, and both the EU [12] and the US [13] are currently working on big projects in this area. People are starting to see the synergies between multimedia and medical systems [14].

The use of computers to automatically find diseases is an important area of study that has not been fully explored yet. However, it could make medicine and healthcare services better all over the world. Unfortunately, datasets with medical pictures are limited. This would make it difficult to compare studies or even to explore new ones in this domain. Therefore, building a rich dataset of UI gives researchers and doctors a useful tool for studying and diagnosing certain diseases using ultrasound imaging. Thus, this paper presents a standardized and labelled dataset of ultrasound images of GB for study and clinical use. This dataset gives the opportunity to come up with a standard and an automatic way to diagnose GB diseases using high-resolution ultrasound pictures.

2.2. Anatomical landmarks

The GB is a hollow intraperitoneal organ, located in the right upper quadrant of the abdomen. Its primary role is to store bile that is secreted by the liver. Bile is composed of multiple organic substances used mainly for the digestion fat in the small intestine. Given the GB's interconnectedness with the hepatobiliary system, numerous pathologies can be raised. Almost 10–15 % of the adult population are affected by GB disorders, the most common is cholelithiasis (gallstones) [3,15].

A summary of the common GB pathologies is highlighted below and presented in Fig. 1.

Gallstones: They are tiny cholesterol/bile salts and calcium crystals that form inside the GB in the form of solid substances [16]. If a patient has symptomatic gallstones, doctors should be consulted for treatment. The main component of bile is bilirubin, which is mainly the by-product of red-blood-cell destruction. Other compounds, such as cholesterol, salts, and pigments also make up bile. Gallstones often form because of an imbalance in the components that make up bile, (increased cholesterol and bilirubin or decreased bile salts). The size of the gallstone can be as little as a grain of sand or as large as a golf ball. Gallstones can remain asymptomatic until they block the duct that transports bile, which induces a variety of symptoms depending on the anatomical location and the severity of the blockage. This often necessitates treatment, which can take the form of the elective surgical removal of the GB (cholecystectomy).

Cholecystitis: The GB's irritation and inflammation result in cholecystitis [17]. Due to the presence of stones in the GB, such stones might migrate and obstruct the bile duct. This leads to

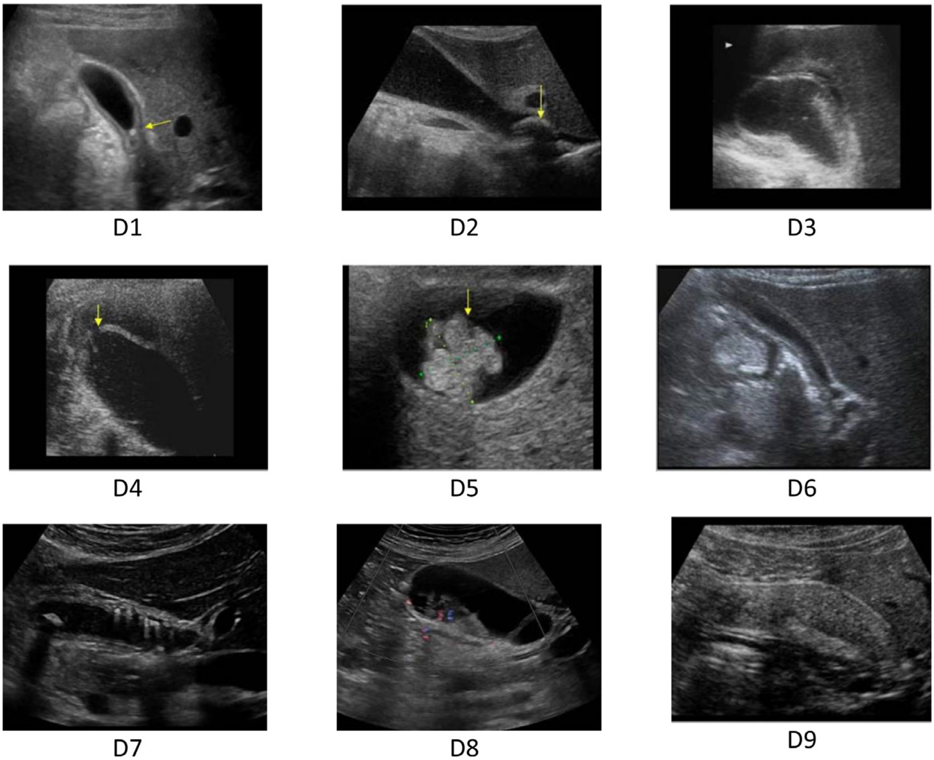

Fig. 1. Gallbladder diseases (D1:D9): (D1) Gallstones, (D2) Cholecystitis, (D3) Gangrenous Cholecystitis, (D4) Perforation of GB, (D5) Polyps and Cholesterol Crystals, (D6) Gallbladder-Wall Thickening, (D7) Adenomyomatosis of the GB, (D8) Carcinoma, (D9) Intraabdominal and Retroperitoneum problems.

the trapping of bile inside the GB, which soon gets infected by bacteria, causing its inflammation due to the accumulation of fluids and local destructive processes. This condition requires urgent medical treatment and later elective surgical procedure.

Gangrenous cholecystitis: It is a critical development of rapid cholecystitis [18,19]. It is considered as a necrosis of the GB due to the luck of blood supply (ischemia) to the GB [20]. It can lead to a life-threatening perforation. It mainly occurs in sufferers with a co-existing immune system depression, diabetics and cardiovascular diseases, and is more common in men. The risk factors for this complication include a critical illness and diabetes and usually diagnosed with High CRP and leucocytosis (inflammatory markers) [21]. Gangrenous-cholecystitis patients often require an urgent cholecystectomy.

Perforation of GB: When the GB's wall does not maintain continuity, the risk of GB perforation rises [22]. GB perforation is one of the most serious and common major complications of the inflamed GB especially in Diabetics and immune compromised patients, and it can lead to death. The identification and treatment of the problems require urgent intervention to prevent serious consequences.

Polyps and Cholesterol Crystals: The buildup of lipids within macrophages in the lining of the GB causes this form of GB disease [23]. Polyps are uncommon with a frequency rate of 2.6 - 9 % of the GB problems based on post-operative and autopsy data. Cholesterol polyps on the internal surface of the GB are benign while endothelial polyps bigger than 10 mm may change into cancer.

Gallbladder-wall thickening: It commonly occurs as a result of a repeated inflammation of the GB followed by healing with the formation of a fibrous tissue. Sometimes, after the inflammation is treated, a localized wall thickening develops due to the long-standing irritation of the wall with sharp stones. This might initiate changes in the type of the cells from inside the GB, which, in turn, may lead to cancer [24].

Adenomyomatosis of the GB: It is an illness characterized by an aberrant mucosal epithelial hypertrophy resulting in the so-called Luschka's crypts in the GB's wall [25]. The condition has three types: 1) fundal (localized), 2) generalized (diffuse), and 3) segmental. The chronic GB infection is an important predisposing factor although its pathophysiology and etiology are unknown. It has a frequency rate of between 1 % and 9 % in cholecystectomy specimens, with an equal sex proportion, and it becomes more common after the age of 50.

Carcinoma: GB cancer is a very rare tumour, with a rate of 1:100,000. It occurs in people over 70 years of age; it is more common in females than males (2:1). Almost all patients with this cancer have gallstones inside their GBs, but most people with gallstones do not develop GB cancer [26]. Carcinoma originates from the tissue that lines the internal walls of the organs, such as the kidney, liver and GB. Carcinoma can spread to other parts of the body or remain confined to a specific area. There are various varieties of GB carcinoma, including invasive carcinoma and carcinoma in situ. The only way to survive this cancer is to receive an early diagnosis and treatment before it spreads.

Intraabdominal and Retroperitoneum problems: The abdomen and retroperitoneum are anatomical regions within the abdominopelvic cavity [27]. It is best visible by magnetic-resonance imaging (MRI) or computed tomography (CT) on an axial transversal section. Complicated GB cancer with spreading to retroperitoneal structures e.g. to lymph node can be detected by Ultrasound.

3. Experimental Design, Materials and Methods

3.1. Methods

The general workflow to produce the UIdataGB dataset is illustrated in Fig. 2. The dataset is composed of ultrasound images of the GB organ from inside the gastrointestinal tract. This dataset comprises JPEG images of the gastrointestinal tract. All these high-quality UI are the result of cutting-edge technologies, specifically Siemens Acuson X700, Philips Affiniti 70, Philips CX50, and Canon Viamo c100 ultrasound machines. The bulk of the training data was collected over the course of four years from four different medical facilities located in Baghdad, Iraq, which are the City of Medicine Teaching Hospital's Gastroenterology department, Al-Numan Teaching Hospital Specialized Gastroenterology Center and Jenin Hospital. Many specialists like medical staff members and expert doctors contributed to gathering images of the dataset. In a first step, all images were painstakingly classified according to disease types by medical professionals at Jenin Hospital's Specialized Gastroenterology Center. In a second step, senior specialists checked the quality of images.

3.2. Data preprocessing

Image preprocessing is a crucial step before feeding information into ML and DL algorithms. Several steps were taken to correctly prepare and process the images in order to be used for research. The original images had a dimension of 450×600 pixels with an aspect ratio of 3:4, a horizontal resolution of 150 pixels, and a vertical resolution of 150 pixels. The bit depth was 24, and the total number of images was 10,692. We resized all the images to a dimension of 900×1200 pixels, a horizontal resolution of 600 pixels, and a vertical resolution of 600 pixels while keeping the aspect ratio to ensure consistency across the dataset. This step was important to avoid potential biases and enable accurate comparisons between images. Following that, we used data augmentation methods to expand the dataset and improve the robustness of the

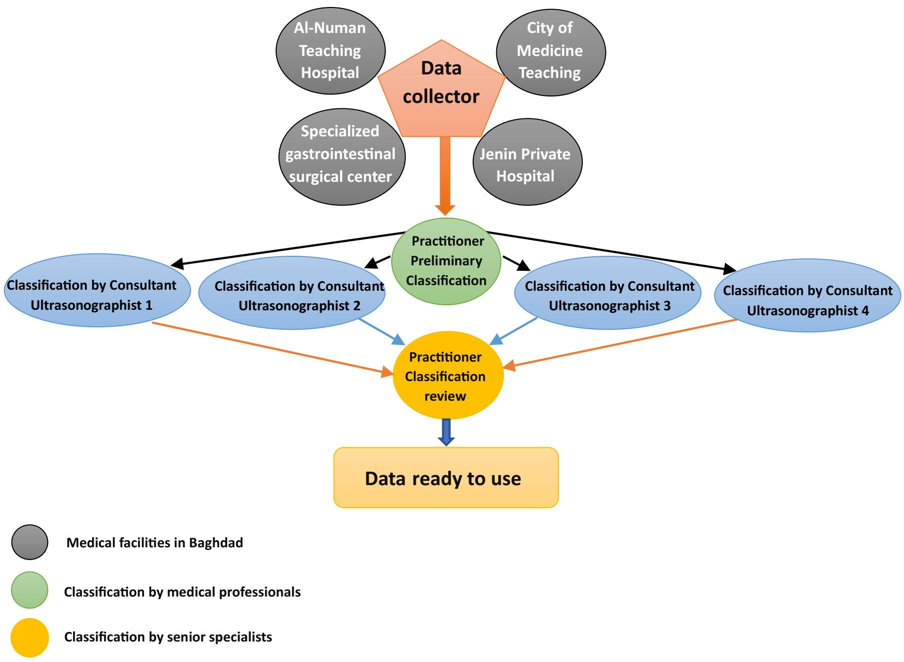

Fig. 2. General workflow of the collected data.

models. Random rotations, flips, and translations, as well as changes in brightness, contrast, and saturation, were among the data augmentation methods employed.

We then normalized the image pixel values to have a zero mean and unit variance to guarantee that differences in pixel intensities across the dataset did not affect the models. This was accomplished with Python's NumPy library. We applied noise reduction to images that had noise because of the limitations of the imaging tools. Python's OpenCV library was used to apply a median filter to each image. To make model training easier, label encoding was used on the categorical labels that were given to each image.

3.3. Data records

The UIdataGB dataset consists of 10692 images, annotated, and verified by medical doctors and experienced radiologists. It includes 9 classes according to anatomical landmarks. Each class contains nearly 1200 images. Therefore, the dataset is balanced in terms of diseases. In total, 1782 patients were involved in the data collection; the number of female images was 6246, with an average age of 63.4, while the number of male images was 4446, with an average age of 59.6.

The number of images is sufficient to be used for different tasks, e.g., image retrieval, ML, DL, and transfer learning (TL), etc. The anatomical landmark of the GB determines the pathological finding like cholecystitis, stone of the GB and polyps.

The dataset consists of images with a resolution of 900×1200 pixels and they are sorted into separate nine folders named according to the content. Tables 1 and 2 show the distribution of diseases in terms of images and patients' numbers as well as the distribution of images according to gender.

Table 1
Summary of dataset details related to disease type.

Disease type	Number of Images	Number of patients	Female	Male
Gallstones	1326	221	137	84
Intraabdominal and Retroperitoneum problems	1170	195	110	85
Cholecystitis	1146	191	102	89
Membranous and gangrenous cholecystitis	1224	204	109	95
Perforation	1062	177	95	82
Polyps and cholesterol crystals	1020	170	99	71
Adenomyomatosis	1164	194	108	86
Carcinoma	1590	265	155	110
Various causes of GB wall thickening	990	165	92	73

Table 2
Summary of gender details.

Sex	Number of images	Average age
Female	6246	47 years
Male	4446	53 years

3.4. Technical validation

In a first step, all images were gathered and classified according to disease types by medical professionals at Jenin Hospital's Specialized Gastroenterology Center. In a second step, the quality of images was checked by senior specialists. Ethical standards were followed during classification. Additionally, in order to evaluate inter-observer variability, a subset of the images was classified separately by numerous experts. The ultimate classifications were decided upon through expert consensus. After that, the specialists implemented a data quality control procedure to guarantee the quality of the dataset and that it is suitable for model training. This entailed manually inspecting a random sample of images for anomalies, blurriness, and other issues that could impact the dataset's quality. In addition to that, we monitored the training process and evaluated the expected models based on the performance metrics. If any problems were discovered, we reevaluated the preprocessing steps and we made some modifications to enhance the quality of the dataset.

Specialists in computer sciences usually need two primordial steps in their works for datasets of UI which differ from one study to another. These steps are:

Step 1: Enhancement of UI from speckle noise
Step 2: Image segmentation method to extract Region of Interest (ROI)

Large numbers of classified images are included in the dataset, which can be used to train and evaluate algorithms for various gallbladder diseases detection and classification. The availability of this dataset can contribute to the development of automated systems that can improve the accuracy and efficiency of the detection process, ultimately leading to better patients' outcomes. In fact, the dataset employed in this study is a helpful tool for scholars in the field of computer-aided diagnosis and can promote the creation of more precise and effective methods for identifying GI abnormalities.

Limitations

The low contrast between the subject and the backdrop in images, along with distortions in ultrasound scanning, may lead to challenges in accurately identifying intra-abdominal organs. This underscores the need to devise sophisticated automatic segmentation and ultrasound image analysis techniques. Additionally, leveraging 3D ultrasound scanning can yield more reliable outcomes compared to 2D imaging. Consequently, our upcoming research will focus on the intricate task of detecting gallbladder disease in ultrasound images using mobile phone photos, videos, and region-based convolutional neural network (R-CNN) technology.

Ethics Statement

Ethical considerations were used during data gathering:

- Patients' permission was obtained prior to the acquisition of images and their personal information were not included in the record.
- To ensure patient anonymity, all personally identifying information was scrubbed from the images.
- The Institutional Review Boards (IRBs) of Baghdad University ensured that the collection of these images was conducted in accordance with the Declaration of Helsinki issued by the World Medical Association and assigned the code: GBD011 On 15-Apr-2022 to this dataset.

Data Availability

Gallblader Diseases Dataset (Original data) (Mendeley Data).

CRediT Author Statement

Amina Turki: Conceptualization, Writing – review & editing; **Ahmed Mahdi Obaid:** Software, Writing – original draft; **Hatem Bellaaj:** Methodology, Formal analysis; **Abdulla AlTaee:** Visualization, Supervision.

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Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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