Democratic and Popular Republic of Algeria
Ministry of Higher Education and Scientific Research
University Centre of Illizi
Institute of Science

Department of Computer Science

Artificial Intelligence & its Applications Master's Thesis

Coccidioidomycosis Detection and Classification using Deep learning

Authors:

- Rayane Chegrouche
  rayane.chegrouche@cuillizi.dz

Advisors:

- Dr. Rim Gasmi
  Gasmi.rim@cuillizi.dz

Examining Committee:

- Mr.chouaib messikh
  messikh.chouaib@cuillizi.dz
- Mr.RIADH MATMAt
  riadh.matmat@cuillizi.dz

Academic Year: 2025

Abstract

In this study, we propose a deep learning-based system for coccidiosis diagnosis, employing two main approaches: classification and detection. For classification, we evaluate the performance of six deep learning algorithms by training them on datasets containing images of healthy lung tissue and tissue infected with Valley fever. For detection, we use five algorithms, including YOLOv 11, to identify the locations of spherical fungi within infected lung tissue. We focus on analyzing the performance of each model using precise metrics including precision, recall, map, and F1 score. This study highlights the effectiveness of using deep learning in accurately detecting fungal coccidiosis and reducing the likelihood of misdiagnosis, thus enhancing the accuracy and speed of medical intervention in infected cases.

Key words: Deep learning,classification,detection, YOLO, coccidioidomycosis, precision,map, recall,F1 score..

ملخص

في هذه الدراسة، نقترح نظامًا قائمًا على التعلم العميق لتشخيص داء الكوكسيديا، من خلال اتباع نهجين رئيسيين: التصنيف والكشف. بالنسبة لنهج التصنيف، قمنا بتقييم أداء ستة خوارزميات تعلم عميق بعد تدريبها على مجموعات بيانات تحتوي على صور لأنسجة رئوية سليمة وأخرى مصابة بحمى الوادي. أما في نهج الكشف، فقد استخدمنا خمس خوارزميات، من بينها YOLOv11، لتحديد مواقع الفطريات الكروية داخل الأنسجة الرئوية المصابة. نركز في دراستنا على تحليل أداء كل نموذج باستخدام معايير دقيقة تشمل الدقة والاسترجاع، والمعدل المتوسط للدقة (mAP)، وتقييم F1. تسلط هذه الدراسة الضوء على فعالية استخدام التعلم العميق في اكتشاف داء الكوكسيديا الفطري بدقة عالية وتقليل احتمالات التشخيص الخاطئ، مما يسهم في تحسين دقة وسرعة التدخل الطبي في الحالات المصابة.

الكلمات المفتاحية: التعلم العميق، التصنيف، الكشف، YOLO، داء الكوكسيديا الفطري، mAP, precision, recall, F1 score.

Acknowledgements

Praise be to God first and the last, and thank him a lot for his guidance and grace. I extend my sincere thanks and gratitude to the honorable supervisors, Mrs. Gasmi RIM, thank you very much for what you presented to me, and for your guidance and advice. I also thank with all my heart my beloved mother, who was my support and inspiration, and my father, my brothers Adme , Baha and sisters Aridj and Hiba for their support and continuous assistance. I should not forget also to give my thanks to my dear, who always supported me. Thank you very much

Contents

List of Figures

Chapter 1

Introduction

1.1 Introduction

Valley fever is a fungal infection caused by coccidia, resulting from the inhalation of spores of certain fungi. These fungi live in the soil, and coccidiosis initially appears as an acute respiratory infection that may resemble pneumonia in symptoms such as fever, cough, and high temperature. However, with accurate diagnosis and a biopsy of lung tissue, spherical fungi can be observed, causing lung damage. However, accurate identification of these fungi requires a mycologist. With the advancement of artificial intelligence techniques, deep learning methods have shown great potential in classifying medical images and detecting spherical fungi in lung tissue. This study aims to develop a deep learning model capable of classifying healthy and infected lung tissue, as well as detecting spherical fungi within tissue. Chapter 2 covers the definition of Valley fever, its symptoms, and diagnostic methods, while Chapter 3 explains deep learning algorithms used for classification and disease detection. Chapter 4 presents model training results and discusses the best-performing algorithms for classification and detection based on various indicators.

1.2 Background

Valley fever is a fungal infection caused by coccidia, of which there are two types: Coccidia immitis and Coccidia posadaceae. These fungi live in the soil, where their spores are inhaled, leading to pneumonia. The disease initially presents as an acute respiratory infection and is often misdiagnosed as pneumonia. However, after a lung tissue sample and a thorough examination, the causative fungus is identified. Diagnosing valley fever and detecting coccidia requires specialized mycological expertise. With significant advances in artificial intelligence, deep learning techniques, particularly convolutional neural networks (CNNs), have become useful in the classification of medical images. Detection techniques such as YOLO (You Only Look Once) have been successfully used to detect objects in images, enhancing the ability to Precision identify coccidia in infected lung tissue.

1.3 Motivation

Classification of healthy and infected lung tissue using deep Classification of healthy and infected lung tissue using deep learning algorithms. Detection of spherical fungi in infected lung tissue using deep learning techniques. To achieve Precision and correct diagnosis of Valley Fever to improve treatment opportunities and reduce complications.

1.3.1 Research Questions

- How accurate are deep learning models in classifying healthy and infected lung tissue?
- What preprocessing techniques contribute to improving the performance of classification and detection models?
- Can deep learning models accurately identify spherical fungi in lung tissue, including small- scale images?

Specific Aims

- Evaluate the accuracy of the model on different datasets.
- Develop and design a model based on multiple algorithms to classify healthy and infected lung tissue.
- Design a model to detect and identify spherical fungi present in lung tissue.
- Analyze the results of different models to determine the most efficient classification and detection models.
- Train the model using multiple deep learning algorithms to determine the best performance in lung tissue classification and detection of spherical fungi.

Key Objectives

-Development of a deep learning model for the accurate detection of coccidioidomycosis
-Development of a model that classifies healthy and diseased lung tissue
-Development of a learning model to detect spherical fungi in infected lung tissue

Chapter 2

Literature Review

2.1 Introduction

Mycobacterial coccidiosis is an infection caused by the inhalation of fungal spores from species of coccidioides, such as Coccidioides immitis and Coccidioides posadasii. The disease is known by several names, including "Valley Fever," "San Joaquin Valley Fever," "Desert Fever," and "Desert Rheumatism." It is particularly prevalent in the southwestern United States, Central America, and parts of South America, where rates have been significantly higher. This increase has led to a significant increase in healthcare costs, with hospitalization costs exceeding $2 billion. Symptoms range from mild, localized infections to more severe cases that spread to other organs. Although inhalation of spores is the primary route of infection, transmission of the fungus through organ transplants or contaminated wounds is rare. The majority of infected individuals do not experience any noticeable symptoms, but approximately 40% experience flu-like symptoms, such as fever, cough, headache, rash, muscle and joint pain, and general fatigue. In most cases, the immune system clears the infection without medical treatment, but misdiagnosed cases may progress to more severe disease. Diagnosis relies primarily on laboratory tests and clinical assessment, which contribute to early detection. Antifungal treatments also help slow disease progression and minimize tissue damage. This review aims to enhance scientific understanding of coccidiosis and raise awareness of its seriousness as a fungal disease affecting human health.[1] [2]

2.2 What is Coccidioidomycosis ?

Coccidioidomycosis is a fungal infection transmitted by inhaling spores from the environment. It is a windblown fungus that grows in soil and dirt, and humans and animals can become infected when they inhale dust containing the Valley Fever fungus. This fungus typically affects the lungs and causes respiratory symptoms, including cough, fever, chest pain, and fatigue.Once inhaled, C. immitis spores develop into large spores that invade tissues. As the spores enlarge and rupture, each spore releases thousands of small endospores, which may then form new spores. After dissemination, the coccidioidomycosis spores settle in the terminal bronchioles, where they enlarge, become rounded, and form internal septa, forming what are known as spheroidal streptococci. The infection then spreads to the lymphatic vessels and bloodstream, reaching any organ in the body. Sometimes, the disease progresses, causing widespread lung damage, systemic spread, or both. Focal lesions may appear in almost any tissue, most commonly in the skin, subcutaneous tissue, bones (osteomyelitis), joints, and meninges (meningitis). [3] [4] [5]

2.3 The different forms of fungal coccidiosis

About 100,000 people are infected with coccidiosis each year. More than 60% of these people have no symptoms, or they think their symptoms are just a mild flu that goes away without treatment. There are three forms of coccidiosis: acute pulmonary coccidiosis, chronic pulmonary coccidiosis, and disseminated coccidiosis. The acute form begins one to three weeks after exposure to the fungus and is usually mild and resolves without treatment, or it may leave behind a small lesion that develops into a cavity (hollow area). The chronic form sometimes develops years after infection. Disseminated coccidiosis is the most severe form of the disease, affecting about 1% of all cases. It typically affects people with weakened immune systems or pregnant women. This type can spread to the nervous system, bones, joints, or skin (Figure 2.2). Acute coccidiosis (valley fever) is the initial or acute form

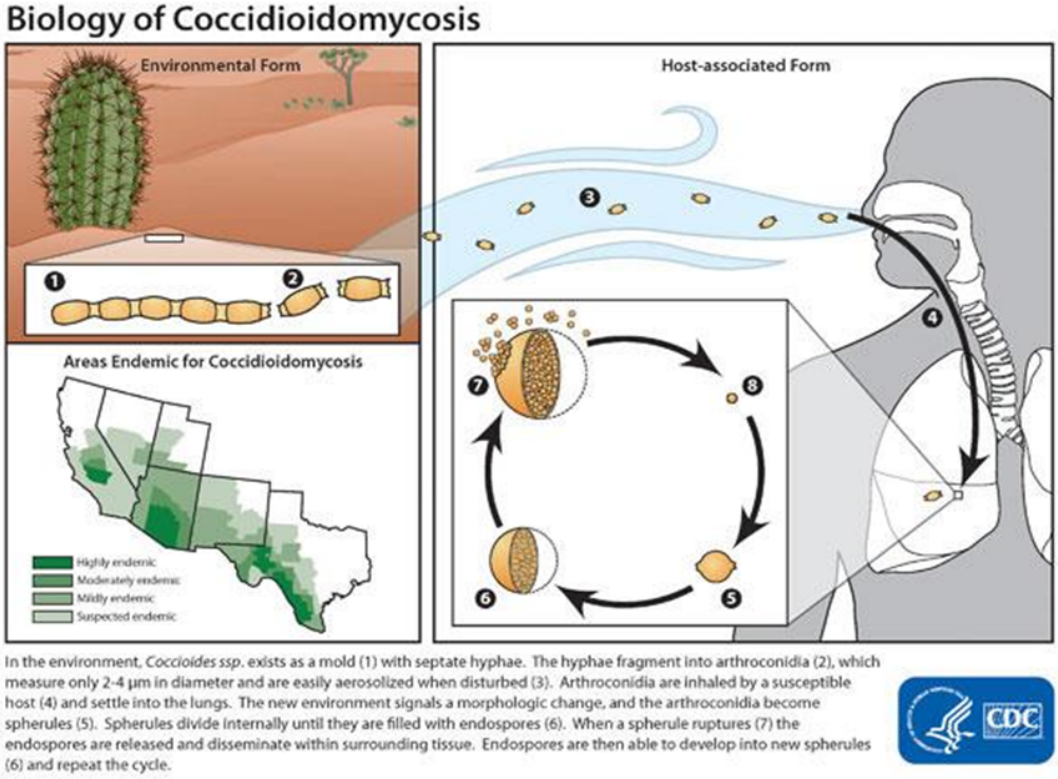

Figure 2.1: Life Cycle of Coccidioides (Biology of Coccidioimycosis).

of coccidiosis, usually mild, with few or no symptoms. Signs and symptoms appear one to three weeks after exposure to the infection. These symptoms tend to be similar to those of influenza. Symptoms range from mild to severe and include fever, cough, fatigue, shortness of breath, headache, chills, night sweats, joint and muscle pain, and a red rash, particularly on the lower legs, but sometimes on the chest, arms, and back. Physical symptoms may be absent or limited to scattered clusters with or without pale areas in the lungs. Some patients develop hypersensitivity to localized respiratory infections, manifesting as arthritis, conjunctivitis, erythema nodosum, or erythema multiforme. If the initial coccidiosis infection does not fully resolve, the disease may progress to a chronic form of pneumonia. This is more common in people with weakened immune systems. Symptoms and signs include a mild fever, weight loss, cough, chest pain, blood-tinged sputum (coughed up), and nodules in the lungs.Disseminated coccidiosis is the most serious and least common form of the disease. It occurs when the infection spreads from the lungs to other parts of the body, most often including the skin, bones, liver, brain, heart, and the membranes that protect the brain and spinal cord (meninges). Signs and symptoms of disseminated disease vary depending on the organs affected and may include nodules, ulcers, and skin lesions that are more severe than the rash that sometimes occurs with other forms of the disease. Painful lesions may also appear in the skull, spine, or other bones. The disease may also be accompanied by painful swelling of the joints, especially the knees or ankles. In some cases, meningitis, an infection of the membranes and fluid surrounding the brain and spinal cord, may develop. [6] [4]

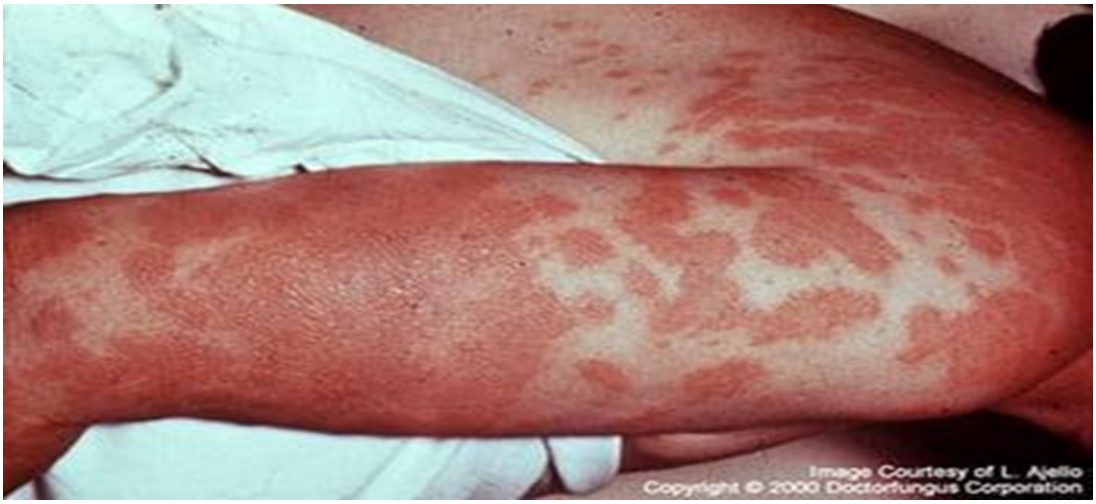

Figure 2.2: example of erythema multiforme due to coccidioidomycosis.

2.4 How is coccidiosis diagnosed?

To diagnose Valley fever, a physician may evaluate the medical history and review the signs and symptoms. Valley fever is difficult to diagnose based on signs and symptoms, as symptoms are often vague and similar to those of other illnesses. Even a chest x-ray does not help doctors distinguish Valley fever from other illnesses. Doctors may order one or more of the following tests: Diagnostic tests for Valley fever may include cultures or detection of nucleic acid from respiratory samples, detection of globulins in tissue samples using histopathology (HP), or detection of specific antibodies in the patient's serum or body fluids. Unfortunately, Coccidia, the fungus that causes Valley fever, is rarely detected in respiratory samples, so the diagnosis is often made by serology, avoiding more invasive diagnostic methods. "Figure 2.3" The following timeline illustrates the "typical" course of Valley fever. Coccidiosis is diagnosed by immunodiffusion, a serological diagnostic test that identi-

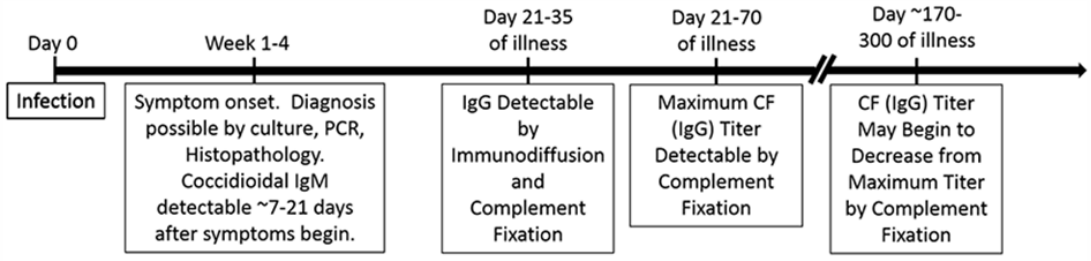

Figure 2.3: timeline outlining a 'typical' Valley Fever disease course.

fies specific antibodies in a patient's serum. The test relies on the ability of antibodies and antigens in different wells of a Gellan plate to diffuse in the gel and form a visible precipitating band at their intersection. When performed in an experienced laboratory, this test is highly sensitive for detecting coccidia-specific antibodies, which aids in the diagnosis of Valley fever. This test is used to detect both IgM antibodies to coccidia (sometimes referred to as coccidia precipitates) and IgG antibodies (sometimes referred to as complement fixation or cystic fibrosis coccidia). Complement

fixation is a serological test used to approximately determine the amount of specific IgG antibodies in a patient's serum. This test relies on two intrinsic properties of complement, a serum component found in vertebrates that contributes to innate immunity. However, it should be noted that not all patients exhibit detectable levels of complement fixation to coccidia. It is estimated that approximately 15% of patients with serologically confirmed Valley Fever do not exhibit detectable levels of complement fixation, because patients with less severe cases do not exhibit appreciable levels of IgG antibodies. Complement fixation testing is less sensitive than other serological methods. The common misconception that complement fixation is a "confirmatory test" for Valley Fever is false.

Diagnosis is also made through imaging tests such as CT scans, MRIs, or chest x-rays. These tests include screening for Valley Fever-associated pneumonia, also known as acute respiratory distress syndrome (ARDS), caused by coccidioidomycosis, and its symptoms include severe bacterial exposure, infiltrates, nodules, cavitation, enlarged mediastinal lymph nodes, and pleural effusions. Nodules in the upper lung are common, but they do not help doctors differentiate Valley Fever from other lung diseases. Because symptoms are similar to pneumonia, in some cases, doctors may perform a skin test to determine if you have or may have valley fever. This involves a small injection in your forearm, similar to a skin test for tuberculosis. If the test is positive, a bump will appear at the injection site, indicating an immune response. Many people test positive without experiencing any symptoms, but negative skin test results are not always accurate. People who have or have been infected may test negative, especially if they have a severe case of valley fever or are taking medications that affect the results. Diagnosis is also made by sputum smear or culture. These tests examine a sample of sputum (phlegm) for the presence of coccidia by visualizing Coccidia spheres in sputum, pleural fluid, cerebrospinal fluid, secretions from bleeding lesions, or biopsy samples. Healthy cocci are typically 20–80 m in diameter, have thick walls, and are filled with small (2–4 m) endospores. Endospores released into tissues from ruptured cocci may be mistaken for unsprouted yeasts. Because coccidia can pose a serious biohazard to laboratory personnel, their culture is not recommended. [6][12][11][4]

2.5 Who is at risk for coccidiosis?

Because coccidia infect the respiratory system, dust exposure is a critical factor in determining disease incidence. The main risk factors for coccidia infection are activities that expose a person to uncontaminated soil dust in endemic areas. Coccidia are unevenly distributed in soil, typically found 10 to 30 cm below the soil surface. Dust storms in endemic areas often follow an outbreak of coccidiosis. In 1977, a severe dust storm carried dust from the San Joaquin Valley to the San Francisco Bay Area, resulting in hundreds of cases of non-endemic coccidiosis in areas north of the San Joaquin Valley. People, especially the elderly, are at greater risk. People with weakened immune systems due to severe lung disease, diabetes, HIV, organ transplantation (lung, kidney, heart, etc.), pregnancy, or taking certain medications (such as steroids or tumor necrosis factor inhibitors for arthritis) are more likely to develop more severe cases of the disease. Certain ethnic groups, such as Filipinos and African Americans, are at greater risk for developing more severe cases of coccidiosis. Patients with exogenous immunosuppression are also at greater risk. Although coccidioidal infection usually causes mild disease and leads to lifelong immunity, 25%–30% of infections result in long-term, self-limited disease; less than 1% of these progress to dissemination, which is serious and sometimes fatal (2–4). Diagnosis and treatment remain a challenge. [5] [7] [8]

2.6 How is coccidiosis treated?

Treatment for mycobacterial coccidiosis continues to evolve. In some cases of primary lung disease, those with more severe symptoms, or those lasting eight weeks or more, antifungal treatment is often not necessary. Oral triazole antifungals are highly effective in treating mycobacterial coccidiosis. Treatment typically lasts several months, with the duration varying depending on the body's response. More severe cases may require hospitalization and intravenous antifungal therapy. For patients with weakened immune systems or extrapulmonary (disseminated) disease, lifelong treatment may be required, and prolonged courses of antifungals may be required for those with extrathoracic spread. In very rare cases, surgery may be required to remove parts of the affected or damaged lung. Fluconazole and itraconazole at a dose of 400 mg daily have proven effective in treating various forms of mycobacterial coccidiosis, including meningitis, although relapse after discontinuation of treatment is a problem. Individuals with compromised cellular immunity are at increased risk of symptomatic mycobacterial coccidiosis, including those infected with HIV, those taking immunosuppressive medications, and those who have undergone solid organ transplants. Pregnant women and African American men have also been identified as two other groups at increased risk of symptomatic and severe infection.[5][9][10]

2.7 Conclusion

Mycobacterium coccidiosis is the oldest and most virulent major fungal disease, and its incidence has increased significantly in recent years in California and Arizona. The clinical manifestations of mycobacterium coccidiosis vary, ranging from asymptomatic to severe, life-threatening infections. Although the vast majority of people with coccidiosis recover without complications, a minority experience a debilitating disease for which there are insufficient pharmacological options for rapid and fully effective treatment. In the absence of newer treatments, discoveries leading to immunotherapy or vaccine prophylaxis may ultimately mitigate the disease. Therefore, physicians in endemic areas must consider the disease in the differential diagnosis and order appropriate investigations. Isolation of Coccidia species is still considered the gold standard for diagnosis; however, because most patients are unable to produce sputum for culture, [13][14]

Bibliography

Bibliography

[1] Johnson RH, Sharma R, Kuran R, Fong I, Heidari A. Coccidioidomycosis: a review. J Investig Med. 2021;69(3):497–506.

[2] ScienceDirect – Coccidioidomycosis

[3] Wikidoc – Coccidioidomycosis

[4] MSD Manual Professional Edition – Coccidioidomycosis. Infectious Diseases

[5] American Thoracic Society – Coccidioidomycosis

[6] Valley fever (coccidioidomycosis) – Symptoms and causes. Mayo Clinic.

[7] Laniado-Laborín R, Alcandar-Schramm JM, Cazares-Adame R. Coccidioidomycosis: An Update. Curr Fungal Infect Rep. 2012;6:113–120.

[8] Fisher MC, Hawkins NJ, Sanglard D, Gurr SJ. Cryptic speciation in human fungal pathogens. Emerg Infect Dis. 2017;23(2):195–204.

[9] Treating and Managing Coccidioidomycosis. American Lung Association.

[10] Ampel NM. The Treatment of Coccidioidomycosis. Rev Inst Med Trop Sao Paulo. 2015;57(1):7–15.

[11] Coccidioides Diagnostic Testing. UC Davis Health.

[12] Primary Pulmonary Infection - Clinical Manifestations. Valley Fever - UC Davis Health.

[13] Stevens DA, Restrepo A, Cortés A. Paracoccidioidomycosis. Infect Dis Clin North Am. 1989;3(4).

[14] Laniado-Labourin R, Alcantar-Schramm JM, Cazares-Adam R. Coccidioidomycosis: An Update. Curr Fungal Infect Rep. 2012;6.