Digital Mammography and Computer-Aided Diagnosis
Breast Cancer

- Breast cancer is second only to lung cancer as a cause of cancer deaths in American women.
- One out of every seven women will be diagnosed with breast cancer in 2007.
- Fortunately, radical mastectomy (breast removal) is rarely needed today with better treatment options.
Female Breast Anatomy

-Breasts consist mainly of fatty tissue interspersed with connective tissue.

-There are also less conspicuous parts:
  - lobes
  - bulbs
  - arteries
  - lymph nodes
Each breast has 15 to 20 sections (lobes) arranged like the petals of a daisy.

Each lobe has many smaller structures (lobules) that end in tiny sacs (bulbs).

Bulbs can produce milk in response to hormonal signals.
Ducts

- Lobes, Lobules and bulbs, are linked by a network of thin tubes (ducts)
- Ducts carry milk from bulbs toward dark area of skin in the center of the breast (areola)
- Ducts join together into larger ducts ending at the nipple, where milk is delivered
Stroma

- Space around the lobules and ducts are filled with fatty tissue and ligaments (stroma)
- The fat gives the breast its size and shape
- The milk-producing structures are nearly the same in all women
Muscles

- Breast has no muscle tissue
- There are muscles underneath the breasts separating them from the ribs
Blood Vessels

Oxygen, nutrients, and other life-sustaining nourishment are delivered to breast tissue by the blood in the arteries and capillaries.
A network of vessels (lymph ducts and lymph nodes) helps fight off infection

- **Lymph ducts:** Drain fluid that carries white blood cells (that fight disease) from the breast tissues into lymph nodes under the armpit and behind the breastbone.

- **Lymph nodes:** Filter harmful bacteria and play a key role in fighting infection.
Three Types of Vessels

1. Lobules → Ducts → Nipple → Milk
2. Lymph Nodes ← Lymph Vessels
3. Bacteria ← Blood Vessels

Waste products

Nourishment

Cell life
**Signs and Symptoms**

- The most common sign of breast cancer is a **lump** or thickening in the breast. Often the lump is painless.

- **Other signs include:**
  - a spontaneous clear or bloody discharge from nipple
  - retraction or indentation of nipple
  - change in size or contours of the breast
  - redness or pitting of skin over the breast, like the skin of an orange
Noncancerous Conditions

- **Fibrocystic changes**: Lumpiness, thickening and swelling, often associated with a woman’s period
- **Cysts**: Fluid-filled lumps can range from very tiny to about the size of an egg
- **Fibroadenomas**: A solid, round, rubbery lump that moves under skin when touched, occurring most in young women
- **Infections**: The breast will likely be red, warm, tender and lumpy
- **Trauma**: A blow to the breast or a bruise can cause a lump
Noncancerous Conditions

- **Microcalcifications**: Tiny deposits of calcium can appear anywhere in a breast and often show up on a mammogram.
  - Most women have one or more areas of microcalcifications of various sizes.
  - They are not the result of calcium supplements.
  - Majority of calcium deposits are harmless.
  - A small percentage may be precancerous or cancer (biopsy is sometimes recommended).
Causes of Noncancerous Conditions

- Some of the cells begin growing abnormally.
- These cells divide more rapidly than healthy cells do and may spread through the breast, to the lymph or to other parts of the body (metastasize).
- The most common type of breast cancer begins in the milk-production ducts, but cancer may also occur in the lobules or in other breast tissue.
Normal Breast

Breast profile

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<td>C</td>
<td>dilated section of duct to hold milk</td>
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<td>D</td>
<td>nipple</td>
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<td>E</td>
<td>fat</td>
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<td>pectoralis major muscle</td>
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<td>chest wall/rib cage</td>
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Enlargement

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<td>A</td>
<td>normal duct cells</td>
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<td>B</td>
<td>basement membrane</td>
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<tr>
<td>C</td>
<td>lumen (center of duct)</td>
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Ductal Carcinoma in situ (DCIS)

Breast profile

A ducts
B lobules
C dilated section of duct to hold milk
D nipple
E fat
F pectoralis major muscle
G chest wall/rib cage

Enlargement

A normal duct cells
B ductal cancer cells *(divide more rapidly)*
C basement membrane
D lumen (center of duct)
Invasive Ductal Carcinoma (IDC)

- IDC accounts for about 80% of all breast cancers
- The cancer has spread to the surrounding tissues
- Carcinoma refers to any cancer that begins in the skin or other tissues that cover internal organs
Range of Ductal Carcinoma in situ
Invasive Lobular Carcinoma (ILC)

Breast profile

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<td>B</td>
<td>Lobular cancer cells breaking through the basement membrane</td>
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Cancer Can also Invade Lymph or Blood Vessels

Breast profile
A  blood vessels
B  lymph ducts

Enlargement
A  normal duct cells
B  cancer cells
C  basement membrane
D  lymph duct
E  blood vessel
F  breast tissue

Illustration © Mary K. Bryson
Mammography

- Use a low-dose x-ray system to examine breasts
- Digital mammography replaces x-ray film by solid-state detectors that convert x-rays into electrical signals. These signals are used to produce images that can be displayed on a computer screen (similar to digital cameras)
- Mammography can show changes in the breast up to two years before a physician can feel them
Mammography Equipment
Computer-Aided Diagnosis

- Mammography allows for efficient diagnosis of breast cancers at an earlier stage
- Radiologists misdiagnose 10-30% of the malignant cases
- Of the cases sent for surgical biopsy, only 10-20% are actually malignant
- CAD systems can assist radiologists to reduce the above problems
What Mammograms Show

Two of the most important mammographic indicators of breast cancers

- **Masses**
- **Microcalcifications**: Tiny flecks of calcium - like grains of salt - in the soft tissue of the breast that can sometimes indicate an early cancer.
Detection of Malignant Masses

Malignant masses have a more spiculated appearance
Mammogram - Difficult Case

- Heterogeneously dense breast
  - Cancer can be difficult to detect with this type of breast tissue
- The fibro glandular tissue (white areas) may hide the tumor
  - The breasts of younger women contain more glands and ligaments resulting in dense breast tissue
Mammogram - Easier Case

- With age, breast tissue becomes fattier and has fewer glands
- *Cancer is relatively easy to detect in this type of breast tissue*
Different Views

Side-to-Side

MRI - Cancer can have a unique appearance – many small irregular white areas that turned out to be cancer (used for diagnosis)

Top-to-Bottom
Feature: Spiculation [Huo et al.]

- Extract the mass using a region-growing technique
- The maximum gradient and its angle relative to the radial direction are computed
- Calculate the full-width at half-maximum (FWHM) from the cumulative gradient orientation histogram
Feature: Spiculation [Chan et al.]

- Determine the outline of the segmented mass
- Obtain the rubber-band-straightening-transformed image
  - The spicules become approximately aligned in a similar direction
- The rectangular region can then be subjected to texture analysis
Breast Calcifications

Calcifications show up as white spots on a mammogram

Round well-defined, Larger calcifications are more likely benign

Tight cluster of tiny, Irregularly Shaped calcifications may indicate cancer
Calcification Features

- **The morphology** of individual calcification, e.g., shape, area, and brightness

- **The heterogeneity** of individual features characterized by the mean, the standard deviation, and the maximum value for each feature.

- **Cluster features** such as total area, compactness
Computer-Aided Diagnosis Using Database Technology

- Content-based image retrieval techniques can provide radiologists “visual aids” to increase confidence in their diagnosis.

- The database consists of a large number of images with verified pathology results.

- Diagnosis is done by submitting the suspected mass region as a query to retrieve similar cases from the database.
A Mammography CAD System

- Probability of malignancy
- Similar images of known diagnosis
- Indicates the unknown lesion relative to all lesions in the database