

Wireless Capsule Endoscopy (WCE)

by

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Outline:

- **What is Endoscopy?**
- **History of Small Bowel Exploration**
- **Introduction to Wireless Capsule Endoscopy (WCE)**
- **Advantages and disadvantages of WCE**
- **Future of WCE**
- **Summary**
- **Our Research Activities on WCE @ XJTLU**

What is endoscopy?

- It means looking inside and typically refers to **looking inside the body for medical reasons using an *Endoscope***
- An endoscope **is a flexible camera** that travels into body's cavities to directly investigate the digestive tract, colon or throat
- These tools are long, flexible cords about 9 mm wide.
- Because of the cord is so wide the **patients must be sedated**

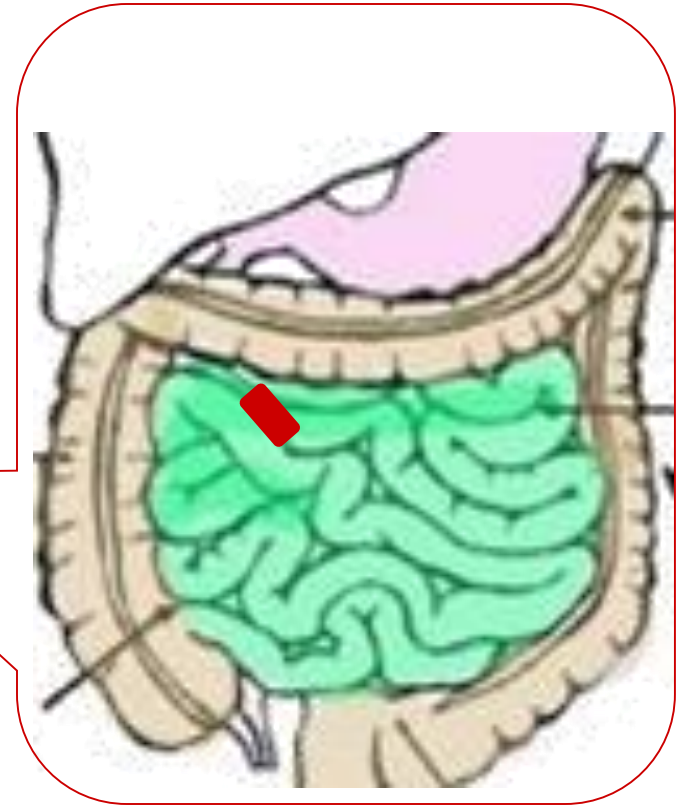
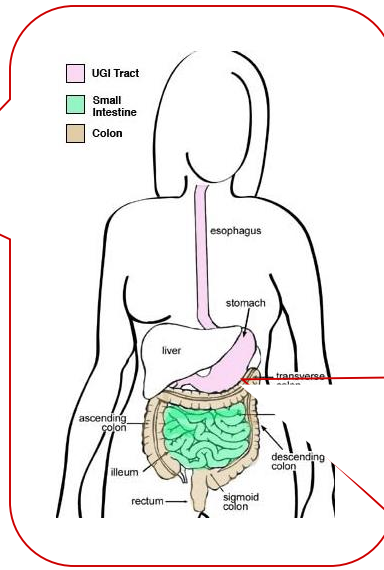
- **History of Small Bowel Exploration**

- Use of Gastrosopes and colonoscopes
- Sonde Enteroscopes
- Development of push enteroscopes
- Capsule Endoscopy (2001)
 - Given; Olympus; IntroMedics (Korea); OMOM (China)
- Double Balloon/Single Balloon Enteroscopy (Japan 2001)



Wireless Capsule Endoscopy (WCE)

- Wireless capsule endoscopy:



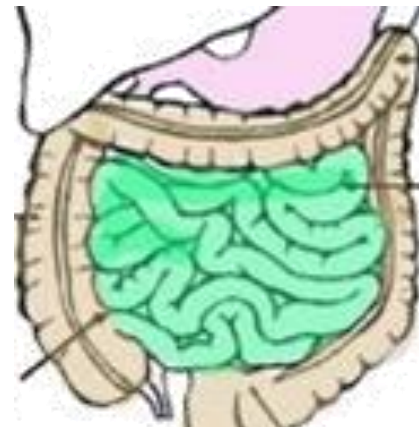
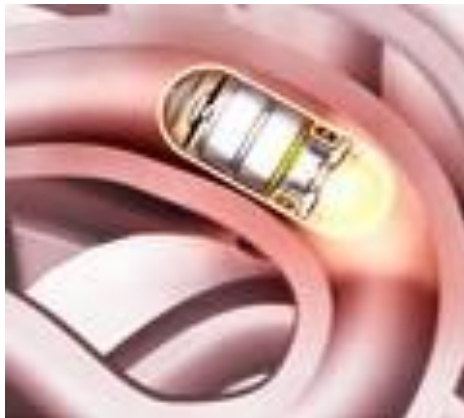
- Is a **swallowed** electronic radio-telemetry device
- Is a **non-invasive** technique, enables the **visualization** of the **small intestine/colono** mucosa (average seven meters) for **diagnosing** purposes, while **eliminating** the **discomfort** of patients

• Wireless Capsule Endoscopy (WCE)

- First reported in the 1950s
 - To measure temperature, pressure and pH
 - Technological advances made video imaging possible starting from 1980s
- It has been approved in USA, by the *Food and Drug Administration (FDA)*, in 2001
- The organization of American Cancer Society reported that the total number of cancer related to GI tract is about 149,530 in the United State only for 2010
- Timely detection and diagnoses are extremely important since the majority of the GI related cancers at early-stage are curable

• Why to use wireless capsule endoscopy ?

- Most of the small intestine, lies beyond the reach of the traditional endoscopy techniques
- Diagnose the small intestine with special imaging techniques like Computed Tomography Scan (CT) or Magnetic Resonance Imaging (MRI), in general, are not useful



- **Most importantly, you don't want this to happen!!!**



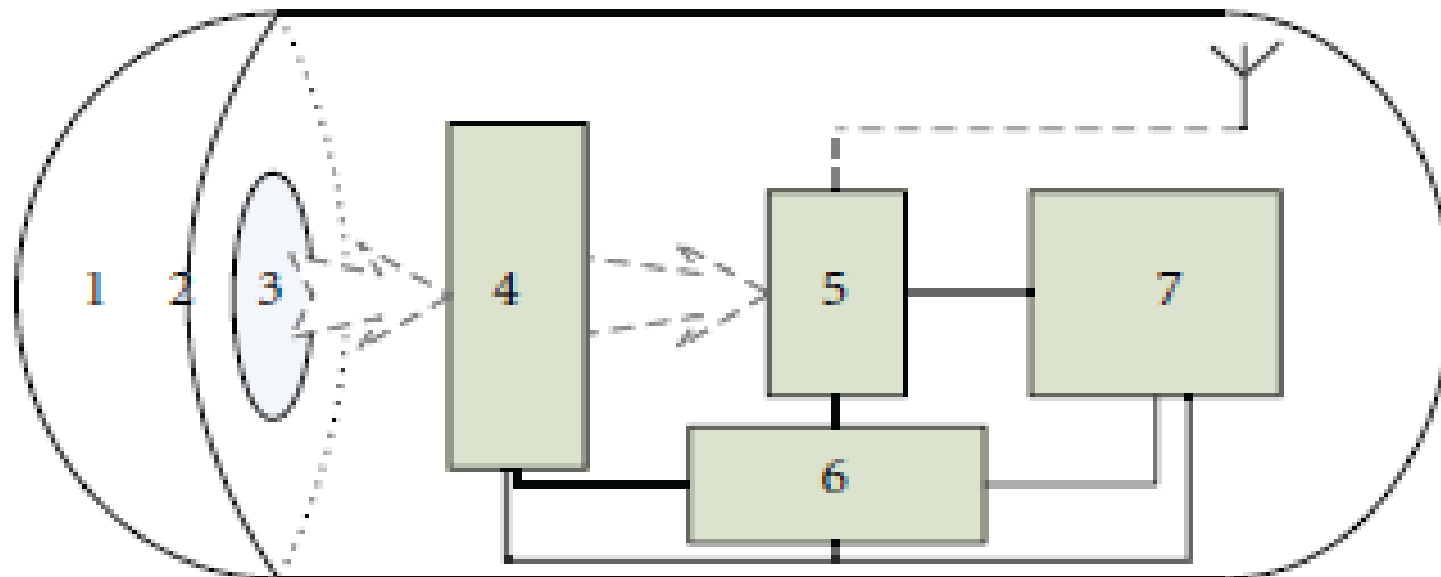
Wireless capsule endoscopy

- **Design specifications (transmitter):**

- Disposable plastic capsule
- 3.7 grams, 11 mm, diameter, 26 mm long
- 140 degree field of view, 1:8 magnification
- Minimal size detection: 0.1mm



Wireless capsule endoscopy



- 1 Optical dome
- 2 LED
- 3 Short-focus lens
- 4 CMOS image sensor

- 5 RF model
- 6 MCU
- 7 Power model

- **Design specifications (transmitter):**

- 2 images per second → >50 000 images total during an 7 hour exam
 - Stomach: One hour
 - Small Intestine: 4 hours
 - Capsule Passage: 2-3 days
 - 18 μ W of power when working at 2 frames per second
 - Picture quality: 256 $\times$ 256 pixel
- Battery life 7 hours

Wireless capsule endoscopy

- **Design specifications (Receiver):**
 - Antenna array of 8 aerials attached to patient
 - Captures images and *determines* location



- **Design specifications (post processing):**
 - Data downloaded from beltpack recorder to workstation
 - Images review time 45 minutes to 2 hours



beltpack recorder

Wireless capsule endoscopy



A typical WCE system contains four parts: capsule endoscope (CE), receiving box, image working station, and software application

- **Indications:**

- Obscure gastrointestinal bleeding
- Evaluation of extent of small intestinal disorders such as Crohn's disease or Celiac sprue
- Abnormal small intestinal imaging
- Suspected mal absorption
- Surveillance of polyposis syndromes involving small intestine

- Some examples

Inflammatory polyp



Ileitis



Crohn's disease



Linear Erosions



Advantages

- **Painless & noninvasive**
- **Eliminates G.I. bleed risk**
- **Procedure requires no sedation**
- **3x length examined compared to Colonoscopy**
- **More accurate than Colonoscopy**

Disadvantages

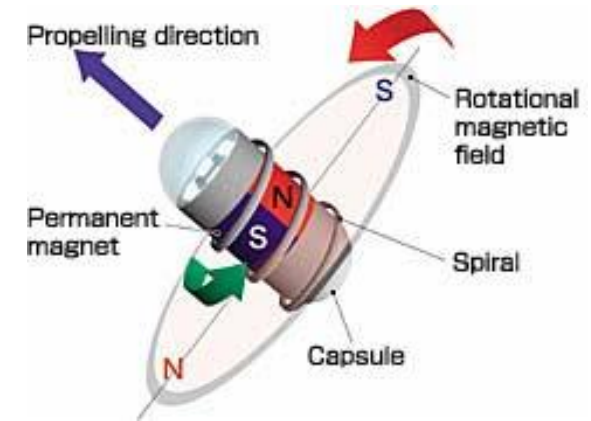
- Capsule can be hard to swallow
- Unable to perform biopsy (Diagnostic only)
- Possible poor visualization
- Inability for precise location
- Can't control image view/direction
- Cannot inflate the bowel
- Limited field of view
- Takes 6-8 hours
- Capsule retention retained/cause bowel obstruction

Future of Capsule Endoscopy

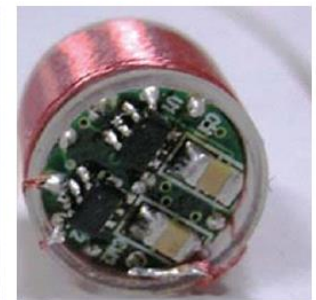
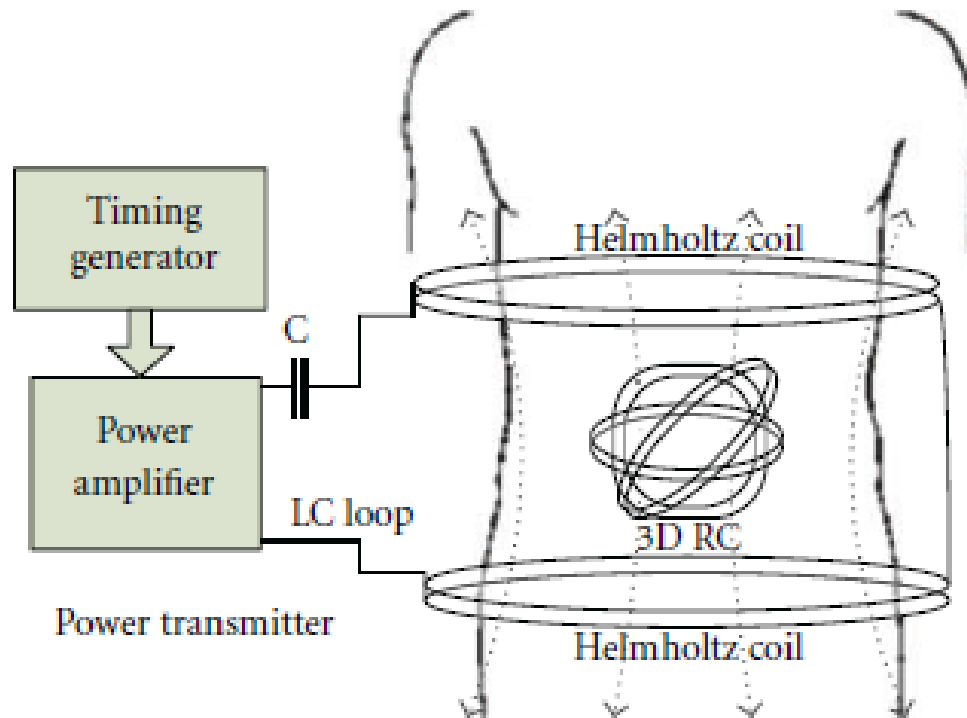
- Colon Capsule
- Steering
- Drug Delivery
- Biopsy
- Wireless power transmission system



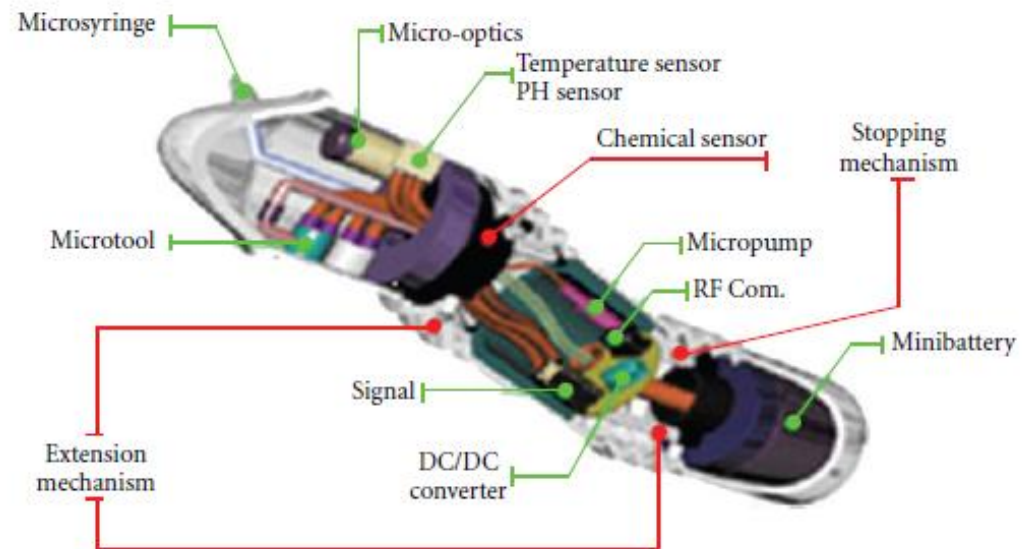
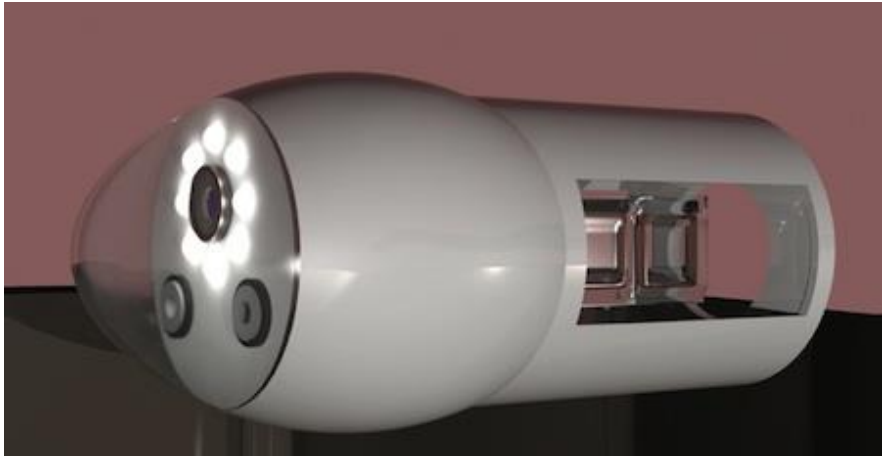
Magnetically Guided Capsule Endoscopy



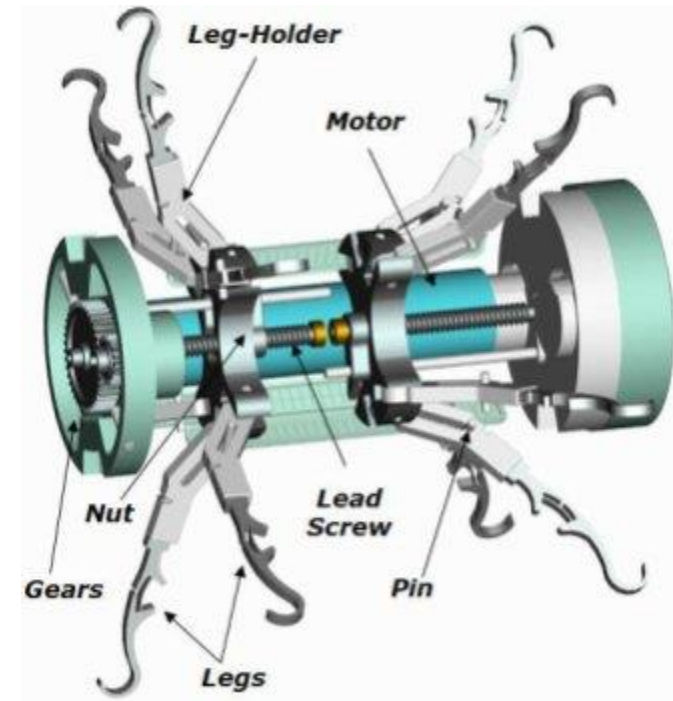
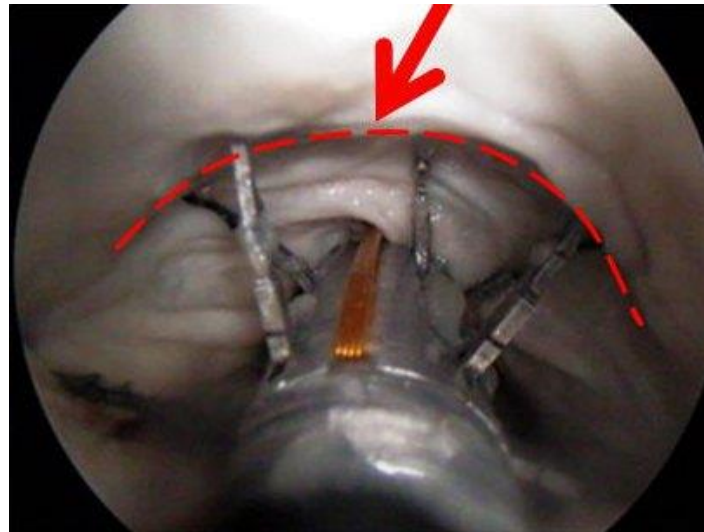
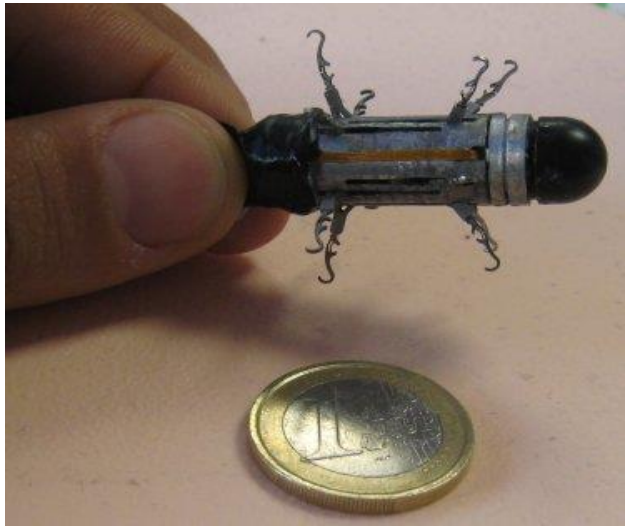
Wireless power transmission system



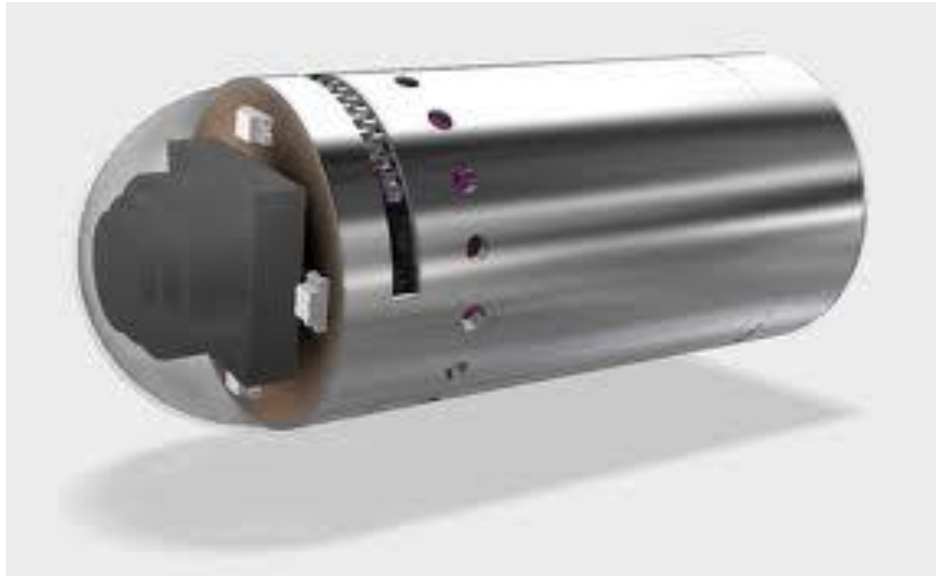
Swimming Capsules



Robotic Capsules



Drug Delivery Capsules



- **Non traditional, less invasive than colonoscopy**
- **Greater imaging with less patient restrictions**
- **Less side effects**
- **Results easily accessible via e-chart**
- **Better data management and trending**
- **However, compared with wired endoscopies, the limited working time, the low frame rate, and the low image resolution limit the wider application**

- To solve above problems, power supply of CE is the bottleneck of this tendency. Wireless power transmission might be solution for this but research efforts are still needed on the safety and transmission efficiency
- Active CE is another tendency and will be the next generation of the WCE but it will not be available shortly.
- The medical robot, which integrates the multifunctions of the endoscopy, the biopsy, the drug delivery, and the microsurgery, is the optimal diagnostic and therapeutic instrument of GI diseases
- Some novel and imaginative locomotion mechanism are proposed but none of them is practicable to be applied in clinic

- **Advance research on WCE**
- **Aims:**
 - efficiency antenna design
 - reliable wireless communication
 - low power WCE
 - self-localization of the WCE (i.e., the device itself attempting to find its own current location)
- **Funded by:**
 - Jiangsu province research fund
 - Suzhou city research fund
 - XJTLU research & development fund
 - Transcend Epoch International Co., Ltd., Hong Kong

- **Research groups involved:**

- High Frequency Research Group
- DATICS Research Group (<http://datics.org/DATICS-CSSE>)
- Wireless Sensor Network Laboratory (<http://datics.org/DATICS-WSNLab>)



- **People:**

- academic staff: 5
- PhD students: 3-6
- research MSc: 3-5
- several students for summer projects

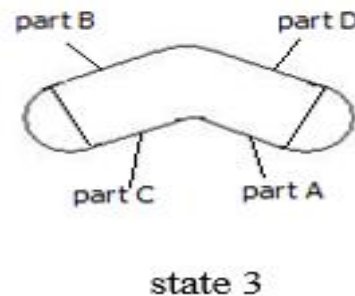
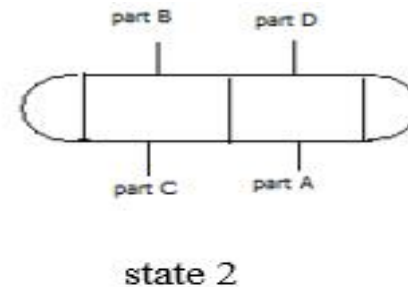
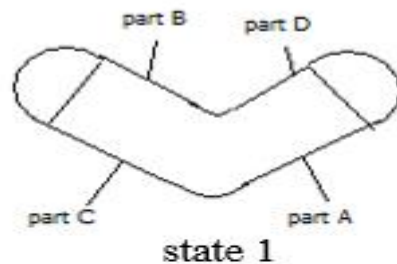
- **UWB (Ultra-Wide Bandwidth) in-body antennas for wireless capsule Endoscopy have been designed**
 - the size of antenna is limited by the size of the capsule
 - desired to be as small as possible
 - around 5-10% smaller than the current antennas
 - new WCE antennas operating at 500 MHz with Ultra-Wide Bandwidth (UWB)
 - the current antennas for WCE are operating at 500 MHz with Ultra-High Frequency (UHF)

- **Development of Battery Management Integrated Circuit (BMIC) for WCE is on-going**
 - aim to design and implement the internal battery used in WCE as small as possible
 - also aim to apply **Artificial Intelligent Algorithms** to manage the power usage of the internal battery used in WCE, in such, the battery will consume less

- **Moveable Wireless Capsule Endoscopy**

- the development of wireless capsule endoscopy equipped with movement mechanism
- the mechanism will make the wireless capsule to move within the human intestine in order to avoid jamming within the place
- the design makes the capsule moving like an insect, which is different from the existing products; and at the same time, users may gain wider range of the visual field by controlling the capsule to wriggle

- **Moveable Wireless Capsule Endoscopy consists of:**
 - a micro-controller
 - a stepper-motor
- **The Mode of motion**



Operations

- According to the order, the motor operates with the clockwise direction
- In opposite order, the motor operates with the anticlockwise direction
- Below figures show the operated status of capsule and the capsule periodical moves with two mentioned statuses



Initial status of capsule



Operated status of capsule

Thanks for listening to me

Q & A please