ISAP2020 Student Design Contest

ISAP 2020 OSAKA JAPAN

Category A. Antenna Design

Goal

To design a character-shaped antenna that satisfies the following specifications.

Specifications

・A part or all of the radiating elements of the designed antenna should be constituted by an English word/acronym (e.g. Antenna, ISAP).

・The word/acronym should have 2 letters and more.

・All the letters should contribute to radiation.

・The design frequency of the antenna is 2402 MHz.

・The antennas size should be within 148 mm by 100 mm, and the antenna thickness should be within 10 mm.

・The antenna is composed of only passive materials. Active components such as amplifiers must not be used.

・A SMA plug-type connector should be attached to the antenna for feeding. The connector is excluded from the antenna size given above.

・Measured or simulated results of the designed antenna must be included in the submitted application form. The document should include the following information:

- ・Description of the antenna design
- ・Geometry
- ・Reflection coefficient
- ・Efficiency
- ・Gain
- ・Current distribution on the character-shaped elements

・In addition to the above indices, a photograph and measured reflection coefficient and gain of the designed antenna must be included in the final design submission.

・In the on-site competition, measurement and exhibition of the antenna performance will be performed. The measurement item will be the received power from a wave source at 2402 MHz (linear polarization). The appearance of the designed antenna will be also evaluated during the final presentation.

Evaluation

The designed antenna is comprehensively evaluated by the submitted documents, on-site measurements and presentation. The evaluation indices will include efficiency, gain, number of characters, and appearance.

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Category B. Localization of RF Sources

Goal

Design and build a system for the localization of RF sources.

Specifications

・The system must be able to measure the transmitted RF signals and localize their positions by methods of your choice.

・The system must not have transmit function. Teams can use an RF system on the market such as Software Defined Radio receiver. The teams can also use a spectrum analyzer that the symposium organizer will prepare. The RF cable and connector for the spectrum analyzer will NOT be prepared.

・The system must be able to operate on a battery or 100V AC, 60Hz. (The organizer prepares Type-A sockets.)

・Total dimensions of the system (sum of width, height, length) must not exceed 200cm, excluding an external computer (if needed).

・The finalists must engage in an on-site "RF localization competition" at the symposium venue to determine the locations of actually hidden transmitters using their system.

・In the competition, the transmitters are hidden in an area of 3m x 3m. The finalists will measure the transmitted signals in the measurement area (see Fig. 1), and determine the locations (X and Y coordinates) of the hidden transmitters within a specified time. At most two teams will engage in a competition simultaneously.

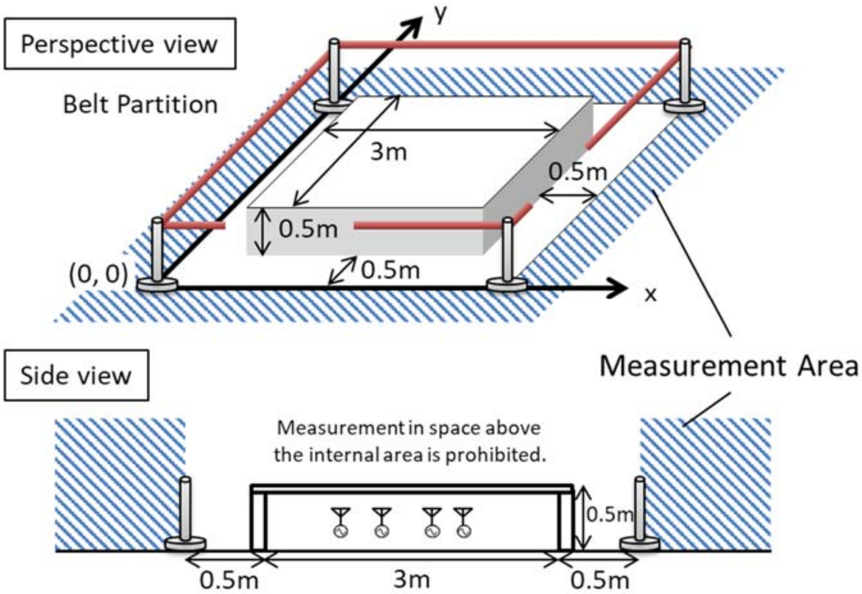

Figure 1 Setup of the transmitters and measurement area.

Specifications of Transmitters

・There will be multiple transmitters.

・Some transmitters will be located on the floor, and a cover of styrene foam will hide them.

・The system should have a capable of tuning to any frequencies within the specified frequency bands.

・The details of the transmitters are shown in the table 1.

Table 1 Specification of transmitters.

Transmitters	A	B	C
Frequency Band	300 – 320 MHz	2.402 - 2.480 GHz	5.012 - 5.025GHz
Output Power (Setting value)	-50dBm	0dBm	10dBm
Transmitter Antenna	λ /2 Dipole antenna	Small antenna	Monopole antenna
Polarization	Horizontal	Unknown	Vertical
Number of transmitters	1 to 3	1 to 3	1 or 2
Type of transmitted signal	CW	Bluetooth Low Energy Beacon (Ch. 37 - 39)	CW

Application and Review Process

・All teams must submit an application form. The document should include the following information:

- ・A description of the preliminary design of the localization system.
- ・A description of the localization method in your system.
- ・A description of the system setup to be build.

・The SDC committee will select finalists based on the above application form. The finalists must submit a document about their final design in the final design submission. The document should include the following information:

- ・A detailed description of the system and localization method in your system.
- ・A detailed description of the system's performance.
- ・Photos of the system.
- ・A list of parts in the system setup.

・The finalists must engage in an on-site "RF localization competition" at the symposium venue to determine the locations of actually hidden transmitters using their system. The finalists also have to briefly explain their system before the competition.

・The score will be assigned to the designs based on the following criteria. The Team with the highest score will win the award.

・Accuracy of the estimated locations of the hidden transmitters. The localization accuracy figure of merit is evaluated by formula to be determined.

- ・Originality and the justification of the system and localization method.
- ・Quality of the system.
- ・Quality of the written materials.

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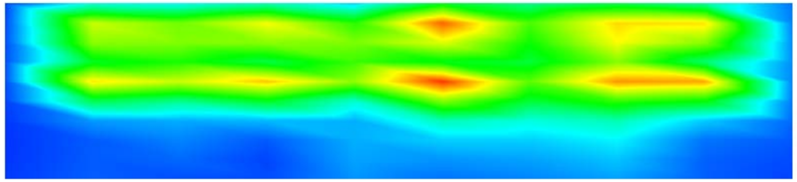
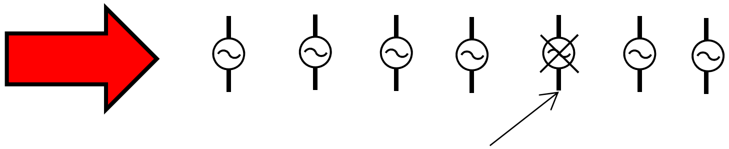
Category C. Inverse Problem

Problem overview

Diagnosis of defective elements in array antennas



Near field distribution



Defective element

- Students develop an algorithm to find defective elements in array antennas.

- The number of defective elements and their positions are expected to be found.

- Near-field data and geometry of the array antennas are given in advance of diagnosis of defective elements.

Problem overview

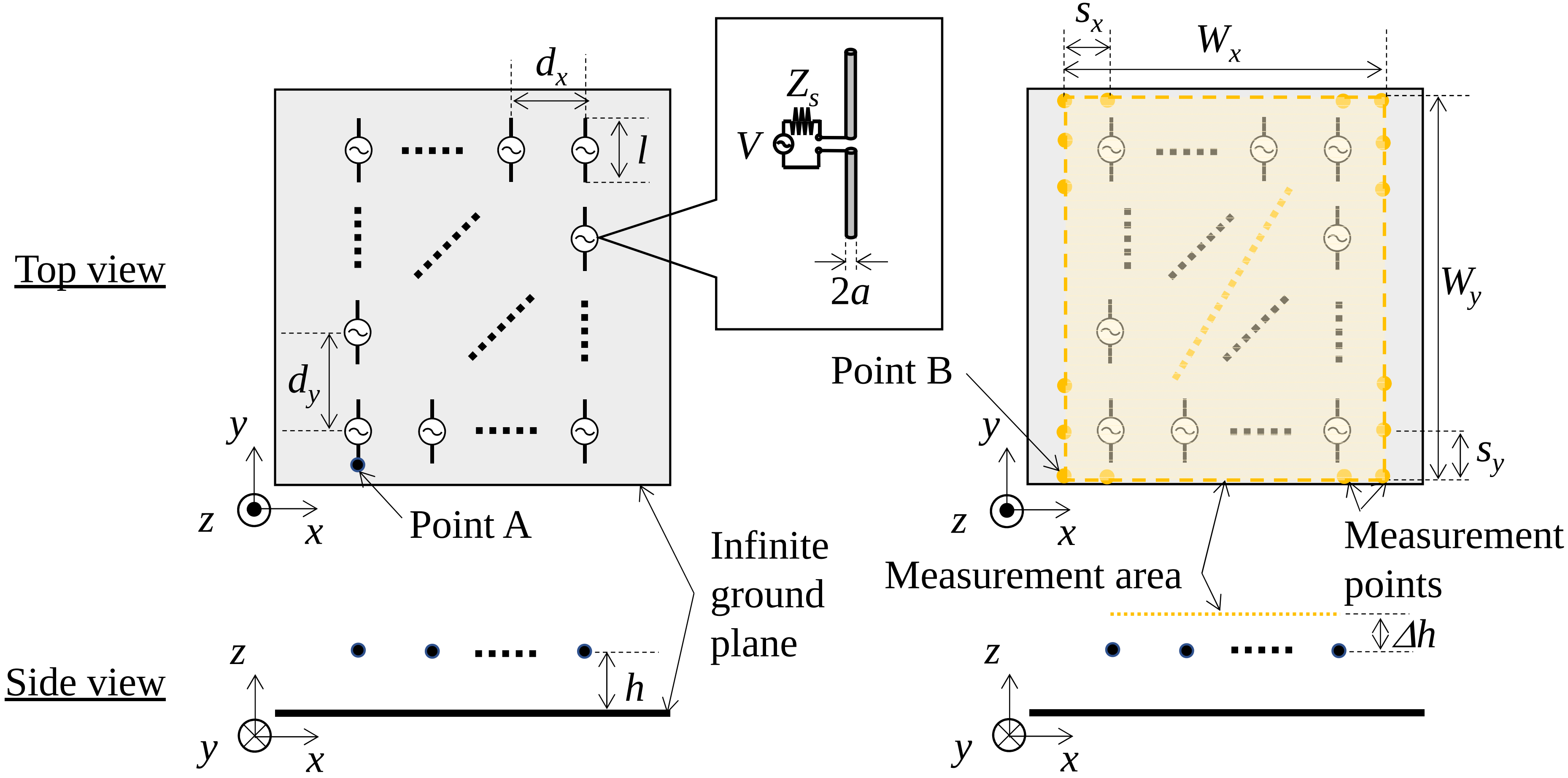
- All antennas are made of PEC (no conductor loss, no dielectric/magnetic medium).
- All antennas are identical except for defective elements.
- Feeding port is center of wire elements.
- Given near-field distribution is calculated using Method of Moments (MoM) for wire antenna.
- Geometry of antennas is given.
- Noise may be added to near field distribution.
- A couple of examples are given in order to test or debug of developed algorithm.
- Format of given near-field data is x [m], y [m], $|E_y|$ [V/m], Phase of E_y [deg.].
- Near-field data is available from following URL,
  http://www.isap2020.org/sdc.html

Data Example

0.0000000000000000E+00	0.0000000000000000E+00	0.1302006185941529E+01	-0.1692766225040980E+03
0.1000000000000000E+00	0.0000000000000000E+00	0.1374331330790637E+01	0.1531028072949372E+03
0.2000000000000000E+00	0.0000000000000000E+00	0.1775542007371312E+01	0.1301743586261456E+03
0.3000000000000000E+00	0.0000000000000000E+00	0.1959338622957370E+01	0.1258114875634234E+03
0.4000000000000000E+00	0.0000000000000000E+00	0.1824603973189982E+01	0.1328872736433964E+03

<u>Antenna under study (AUT)</u>

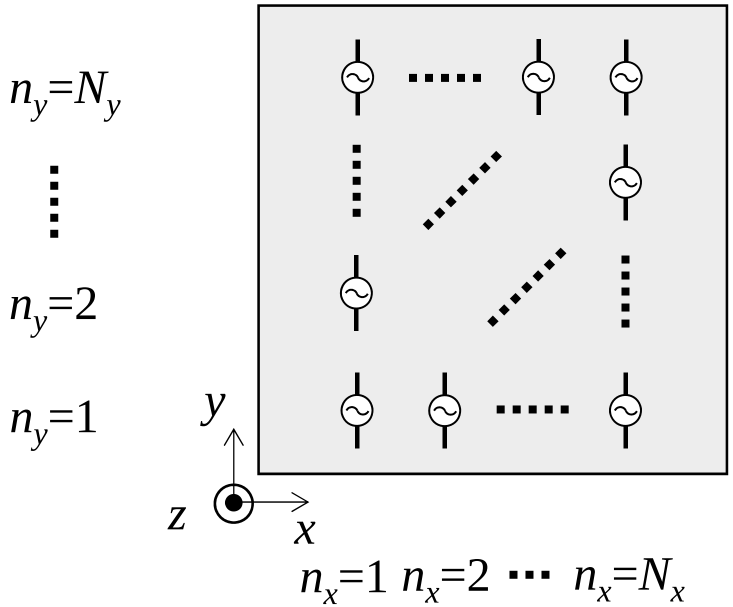
A $N_x \times N_y$ periodic dipole array antenna over infinite PEC ground



- The number of array elements in x and y direction is N_x and N_y, respectively.
- The number of measurement points in x and y direction is M_x and M_y, respectively.
- Point A of antenna geometry (Edge of a dipole antenna) is $(x, y, z)=(0, 0, h)$
- Point B of measurement area (A corner of the area) is $(x, y, z)=(-0.2, -0.2, h+\Delta h)$

<u>Antenna under study (AUT)</u>

A $N_x \times N_y$ periodic dipole array antenna over infinite PEC ground



- Element position is uniquely indicated by (n_x, n_y).
  For example,
  (n_x, n_y)=(1, 1) indicates an array element at left below corner.
  (n_x, n_y)=(1, N_y) indicates an array element at left top corner.
  (n_x, n_y)=(N_x, N_y) indicates an array element at right top corner.

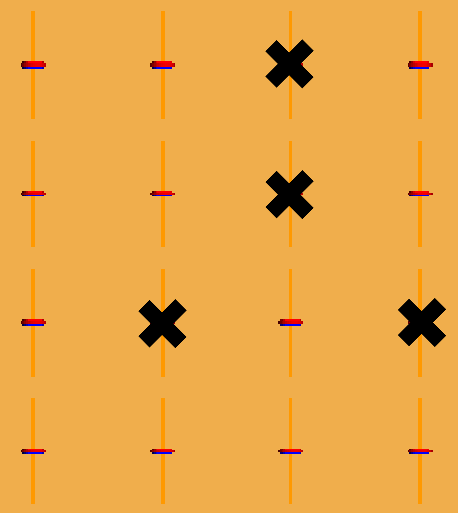
Two Examples for Debug

Parameters and Geometries

Problem example 1: Short circuited defective elements

Array size	$N_x \times N_y = 4 \times 4$
Frequency	300 MHz
Length of dipole antenna	l=0.5 m
Radius of dipole antenna	a=0.001 m
Height of dipole antenna	h=0.25 m
Array spacing in x and y direction	$d_x = d_y = 0.6$ m
Excitations	Uniform and in-phase (V=1 V)
Load impedance at feeding port	$Z_s = 50\ \Omega$
Defective elements	Short circuited (V=0 V and $Z_s = 0\ \Omega$)
Measurement points	$M_x \times M_y = 23 \times 28$
Measurement intervals in x and y direction	$s_x = s_y = 0.1$ m
Measurement area of near field distribution	$W_x \times W_y = (M_x - 1)s_x \times (M_y - 1)s_y = 2.2 \times 2.7\ \mathrm{m}^2$
Height of measurement plane from the array	Δh=0.1 m
Measured data	y-components of complex electric field
Number of defective elements	Unknowns to be obtained
Position of defective elements	Unknowns to be obtained

Problem example 1 Answer



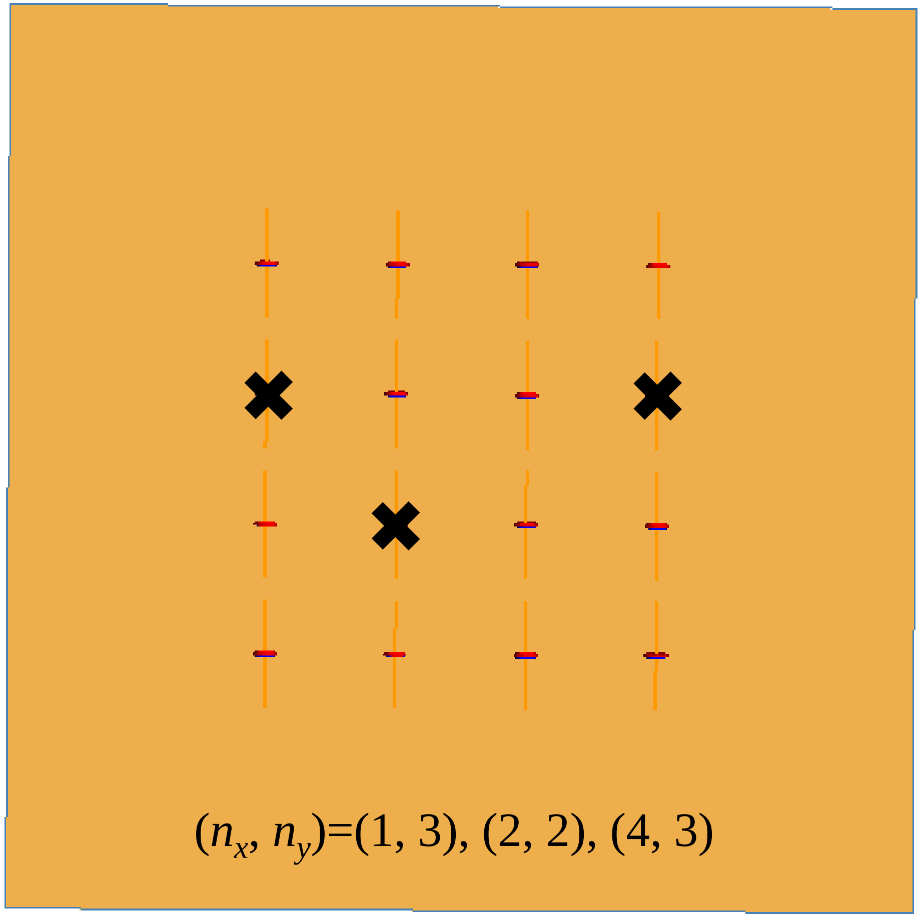
(n_x, n_y)=(2, 2), (3, 3), (3, 4), (4, 2)

Parameters and Geometries

Problem example 2: Open circuited defective elements

Array size	$N_x \times N_y = 4 \times 4$
Frequency	300 MHz
Length of dipole antenna	l=0.5 m
Radius of dipole antenna	a=0.001 m
Height of dipole antenna	h=0.25 m
Array spacing in x and y direction	$d_x = d_y = 0.6$ m
Excitations	Uniform and in-phase (V=1 V)
Load impedance at feeding port	$Z_s = 50\ \Omega$
Defective elements	Open circuited (V=1 V and Z_s=100,000 Ω)
Measurement points	$M_x \times M_y = 23 \times 28$
Measurement intervals in x and y direction	$s_x = s_y = 0.1$ m
Measurement area of near field distribution	$W_x \times W_y = (M_x-1)s_x \times (M_y-1)s_y = 2.2 \times 2.7\ \mathrm{m}^2$
Height of measurement plane from the array	Δh=0.1 m
Measured data	y-components of complex electric field
Number of defective elements	Unknowns to be obtained
Position of defective elements	Unknowns to be obtained

<u>Problem example 2 Answer</u>



Contest Problems

Parameters and Geometries

Problem 1: Abnormal excitation

Array size	$N_x \times N_y$=8 × 8
Frequency	300 MHz
Length of dipole antenna	l=0.5 m
Radius of dipole antenna	a=0.001 m
Height of dipole antenna	h=0.25 m
Array spacing in x and y direction	d_x=0.6 m, d_y=0.8 m
Excitations	Uniform and in-phase (V=1 V)
Load impedance at feeding port	Z_s=50 Ω
Defective elements	Abnormal excitation ($V=e^{j\pi/6}$ V)
Measurement points	$M_x \times M_y$=47×66
Measurement intervals in x and y direction	s_x=s_y=0.1 m
Measurement area of near field distribution	$W_x \times W_y$= $(M_x$-1$)s_x \times (M_y$-1$)s_y$=4.6×6.5 m^2
Height of measurement plane from the array	Δh=0.1 m
Measured data	y-components of complex electric field
Number of defective elements	Unknowns to be obtained
Position of defective elements	Unknowns to be obtained

Parameters and Geometries

Problem 2: Impedance mismatching + noise

Array size	$N_x \times N_y$=**8 × 8**
Frequency	300 MHz
Length of dipole antenna	l=0.5 m
Radius of dipole antenna	a=0.001 m
Height of dipole antenna	h=0.25 m
Array spacing in x and y direction	d_x=0.7 m, d_y=0.7 m
Excitations	Uniform and in-phase (V=1 V)
Load impedance at feeding port	Z_s=50 Ω
Defective elements	Impedance mismatching (Z_s=50 + j1000 Ω)
Measurement points	$M_x \times M_y$=54×59
Measurement intervals in x and y direction	s_x=s_y=0.1 m
Measurement area of near field distribution	$W_x \times W_y$= $(M_x$-1$)s_x \times (M_y$-1$)s_y$=5.3×5.8 m^2
Height of measurement plane from the array	Δh=0.1 m
Measured data	y-components of complex electric field SNR =10 dB
Number of defective elements	Unknowns to be obtained
Position of defective elements	Unknowns to be obtained

Parameters and Geometries

Problem 3: Misalignment + noise

Array size	$N_x \times N_y = 8 \times 8$
Frequency	300 MHz
Length of dipole antenna	l=0.5 m
Radius of dipole antenna	a=0.001 m
Height of dipole antenna	h=0.25 m
Array spacing in x and y direction	d_x=0.8 m, d_y=0.8 m
Excitations	Uniform and in-phase (V=1 V)
Load impedance at feeding port	Z_s=50 Ω
Defective elements	Misalignment in xy direction ($-0.1 \leqq \Delta x \leqq 0.1$ m, $-0.1 \leqq \Delta y \leqq 0.1$ m, or their combination)
Measurement points	$M_x \times M_y = 61 \times 66$
Measurement intervals in x and y direction	$s_x = s_y$=0.1 m
Measurement area of near field distribution	$W_x \times W_y = (M_x-1)s_x \times (M_y-1)s_y = 6 \times 6.5$ m^2
Height of measurement plane from the array	Δh=0.1 m
Measured data	y-components of complex electric field SNR =10 dB
Number of defective elements	Unknowns to be obtained
Position of defective elements	Unknowns to be obtained

Application form

- Each team must submit an application. The application form must include
  - Description of the proposed algorithm
  - Answers of problems*1, *2

    *1An application form including answers of all problems is preferable but an application form is acceptable if it includes answer of one problem at least.)

    *2 For problems 1 and 2, element numbers of defective elements must be answered, e.g. $(n_x, n_y) = (2, 4), (1, 5)$. For problem 3, element numbers and misalignment of defective elements must be answered, e.g. $(n_x, n_y)=(2, 4)$, $\Delta x=0.02$ m, $\Delta y=-0.075$ m.

- The SDC committee will score each application form based on following points.
  - Accuracy of estimation
  - Originality of the proposed method
  - Contribution
  - Completeness of description
- According to the score of each application form, a number of teams will be nominated as finalists. Authors are recommended to highlight above points in their application form.

Final solution submission

- Finalists must be ready for poster presentation during ISAP2020 and must submit a poster data as an final solution submission in advance.
- The poster data should include
  - Description of the proposed algorithm
  - Answers of problems*

  *It is preferable to show answers of problems using graphs as shown in problem examples.
- The poster should be submitted in PDF format (less than 5 MB file size), and should be ready to be displayed on an A0 portrait poster panel.

On-site competition

The finalists are requested to make a poster presentation on-site.

Evaluation

- The SDC committee will score each poster based on
  - Accuracy of estimation
  - Originality of the proposed method
  - Contribution
  - Completeness of description
  - Quality of the poster presentation
- According to the score of each application form and poster, a couple of teams will be awarded.