School of Engineering and Applied Science (SEAS), Ahmedabad University

B.Tech(ICT) Semester V: Wireless Communication (CSE 311)

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- Base Article Title: **On the Joint Impact of SU Mobility and PU Activity in Cognitive Vehicular Networks with Improved Energy Detection** [?]
- **Impact on Detection Probability , Without constant velocity and changing in angle**

1 New Performance Analysis

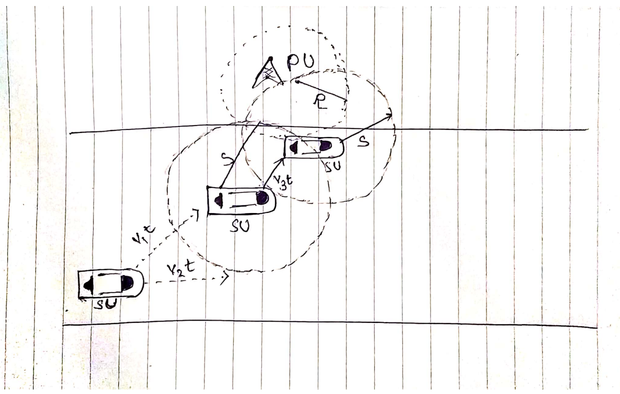
- Our base article has limitations. In the previous system model we have considered that SU is moving in straight line with constant velocity. But in the reality SU can move with different velocities and at different angle. To overcome this limitations , we have considered the system model as shown in the figure below.
- We have implemented or consider the impact of Doppler's effect [2].

$$\mathrm{f} \;= \left(\frac{c \pm v_r}{c \pm v_s}\right) * f_0$$

v_r is the velocity of the receiver(SU) relative to the medium (positive if the receiver(SU) is moving towards the source(PU) and negative if in the opposite direction)
v_s is the velocity of the source(PU) relative to the medium (positive if the source(PU) is moving away from the receiver(SU) and negative if in the opposite direction) But in our case PU is stationary .so $v_s = 0$

Symbol	Description
P_d	Probability of detection
P_{fa}	Probability of false alarm
P_{md} *or* P_m	Probability of miss-detection
CED	Classical energy detection
IED	Improved energy detection
$P(I)$	Probability of PU being inside SU's sensing range
$P(O)$	Probability of PU is outside sensing range of SU.
P	Number of previous sensing events considered
S	Sensing range of SU
R	Protection range of PU
f_c	Carrier Frequency
f_d	Doppler frequency
c	speed of light in air
θ	Angle between PU and SU
M	Number of sensing events

- System Model:



- **Detailed derivation of performance metric-I**

- According to base article, Assuming that the SU and PUs are stationary,Where SU is moving forward on straight road hence having a fixed separation between them. The probability distribution of the distance between SU and PU separated by distance D is obtained distribution of time T = $\frac{D}{V}$ which evaluates to a lognormal distribution

$P(I) = P(R < D \leq S) = F_S(s) - F_R(r) = \frac{1}{2}[erf(\frac{s-\mu_s}{\sigma_s}) - erf(\frac{r-\mu_r}{\sigma_r})]$

$$P(I) = \frac{1}{2}[erf(\frac{\frac{S-D_0}{v} - \mu_t}{\sigma_t}) - erf(\frac{\frac{R-D_0}{v} - \mu_t}{\sigma_t})] \tag{1}$$

- Considering Doppler Effect ,

$$\frac{1}{T} = f_d = \frac{V}{D} = \frac{c-vcos\theta f_c}{c}$$

$$\frac{S-D_0}{v} = \frac{S}{v} - \frac{c}{c-vcos\theta f_c} \tag{2}$$

Similarly for Protection range of PU,

$$\frac{R-D_0}{v} = \frac{R}{v} - \frac{c}{c-vcos\theta f_c} \tag{3}$$

- Putting eq.(2) and eq.(3) in eq(1),

$$P(I) = \frac{1}{2}[erf(\frac{\frac{S}{v} - \frac{c}{c-vcos\theta f_c} - \mu_t}{\sigma_t}) - erf(\frac{\frac{R}{v} - \frac{c}{c-vcos\theta f_c} - \mu_t}{\sigma_t})] \tag{4}$$

where,μ_t and σ_t represent mean and standard deviation of sensing range at time t .P(O) is same as ,

P(O) = 1 - P(I)

- **Detailed derivation of performance metric-II**

PU state sensing by SU	**SU sensing**	**Occurrence**
Idle(Actually Idle)	can sense	Detection
Idle(Actually Busy)	can't sense	Miss Detection
Busy(Actually Idle)	can sense	False Alarm

Now considering f_d in our system model ,then it changes P(I) and P(O) so, results of each Miss-detection and False-alarm will be changed with eq.(4)
Following P_f, P_m equations of CED and IED are from base article,We have already done reproduction of these metrics [**?**] and did small tinkering with P(I),

$$P_f^{CED} = P(f|I) * P(OFF) \tag{5}$$

$$P_m^{CED} = [P(m|I) * P(I) + P(m|O) * P(O)] * P(ON) \tag{6}$$

$$So, P_d^{CED} = 1 - \{[P(m|I) * P(I) + P(m|O) * P(O)] * P(ON)\} \quad (7)$$

$$P_f^{IED} = P_f^{CED} + P_f^{CED} * (1 - P_f^{CED}) * Q(\frac{\lambda - \mu_{avg}}{\sigma_{avg}}) \quad (8)$$

$$P_d^{IED} = P_d^{CED} + P_d^{CED} * (1 - P_d^{CED}) * Q(\frac{\lambda - \mu_{avg}}{\sigma_{avg}}) \quad (9)$$

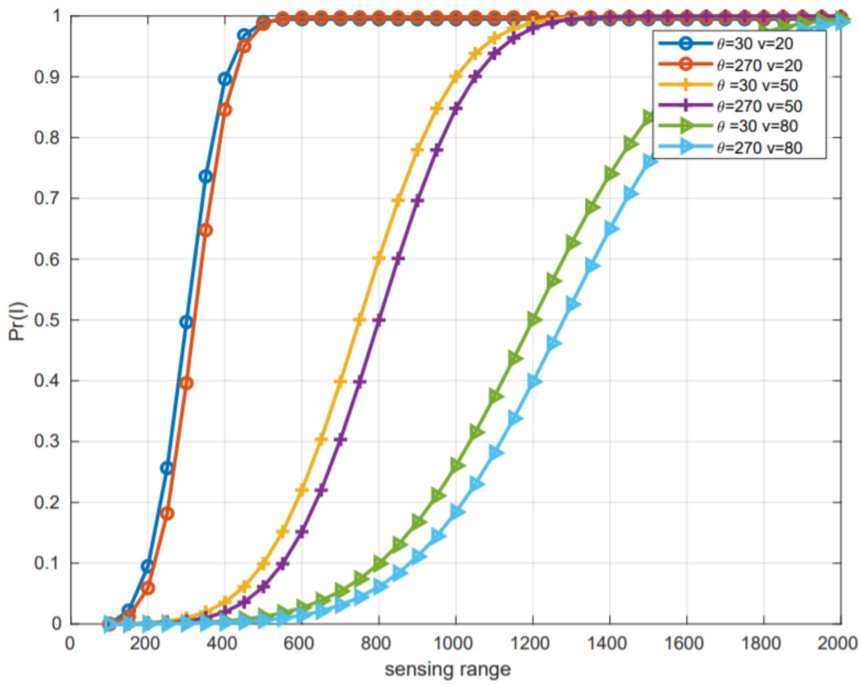
2 New Numerical Results

2.1 Simulation Framework

- **For Figure 1,** The maximum value of sensing range is 2000 meters.Here we take the Protection range R= 100 m,velocity is changing and the theta means direction of SU is also varying with time. Carrier Frequency $f_c = 10^9$ and the speed of light is c = $3*10^8$.This graph is plotted using equation (4).
- **For figure 2,** It represent the probability of false alarm and miss detection ,how it is changing with different velocity and angle .where the sensing Range is S =300,v=10,100 ,θ = 0,300

2.2 Description of Figures

- 2.2.1 : P(I) vs Sensing Range of SU in meters



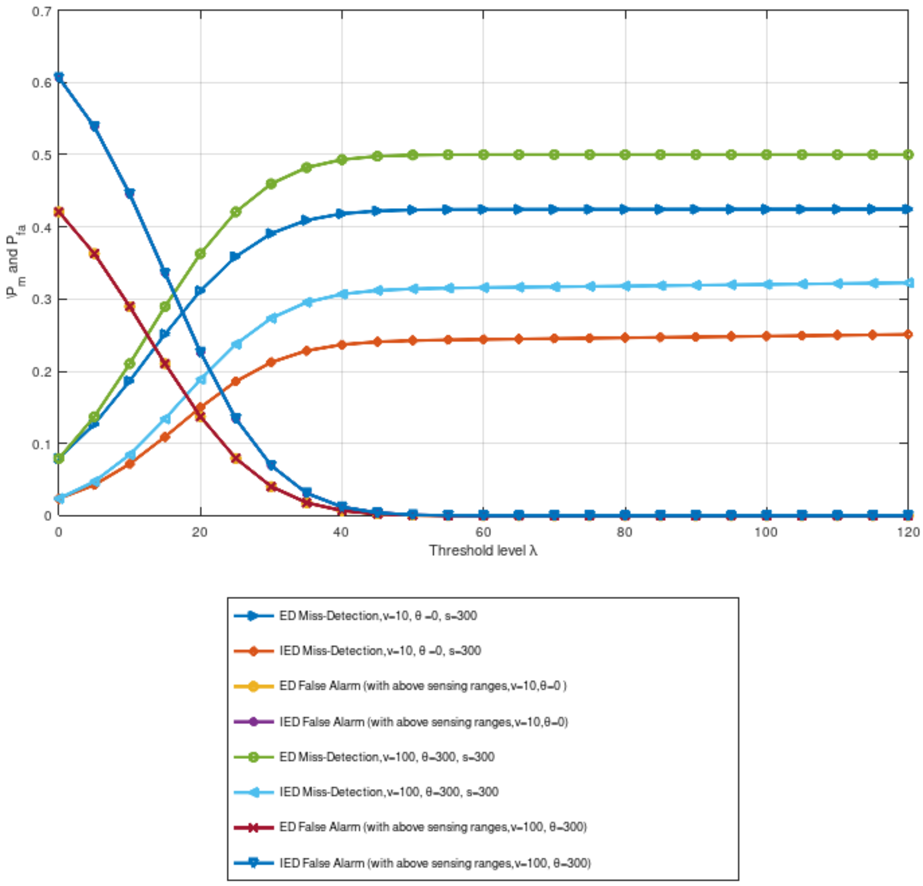
- **Inference:**

  ⋆ Bigger velocity of SU,P(I) is getting with large value of sensing

  ⋆ Smaller value of velocity is better for immediately Sensing

  ⋆ As increasing θ , little bit difference for PU is sensing range of SU range

- 2.2.2 : P_m and P_{fa} vs Threshold value (λ)



- **Inference:**

  ⋆ Miss-detection Probability will increase with increasing the value of Velocity and θ,so velocity as much as possible is better for Spectrum Sensing

  ⋆ No more difference on False alarm Probability which means It is independent of Velocity and θ value

3 Contribution of team members

3.1 Technical contribution of all team members

Tasks	**Mansi**	**Khushi**
Derivation of Performance metric I	✓	✓
Derivation of Performance metric II	✓	✓
Figure 1	✓	✓
Figure 2	✓	✓

3.2 Non-Technical contribution of all team members

Tasks	**Mansi**	**Khushi**
Report	✓	✓
Miro frame work	✓	✓

References

[2] https://scholar.harvard.edu/files/schwartz/files/lecture21-doppler.pdf