Escola Politécnica

Universidade de São Paulo

Pesquisa Científica em ITS

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PTR5917 – Sistemas Inteligentes de Transporte

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Objetivo

Queremos responder às seguintes perguntas:

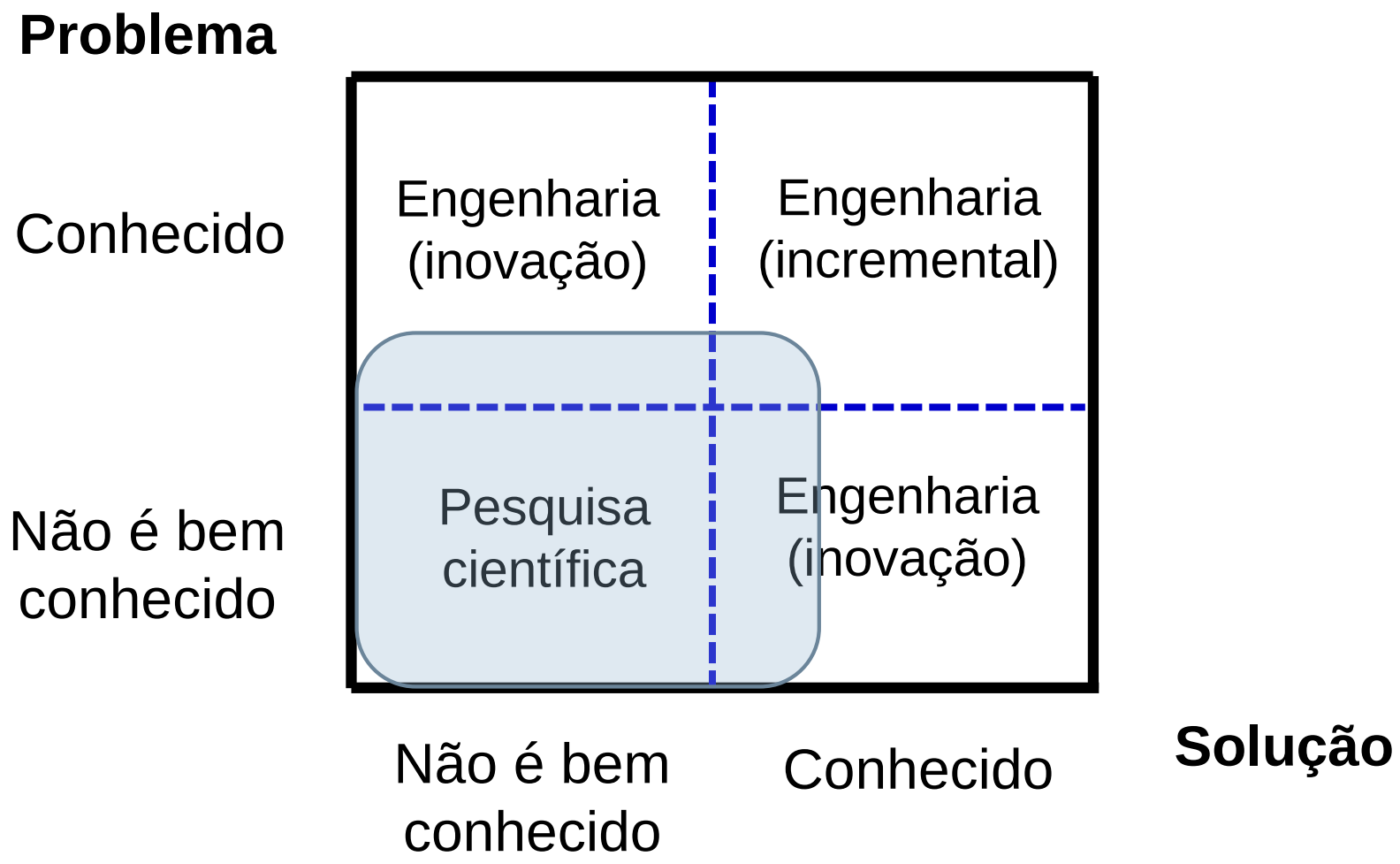
1. **Porque** fazer Pesquisa Científica ?
2. **O que** é uma Pesquisa Científica ?
3. **Como** realizar uma Pesquisa Científica ?
4. **Como** escrever um Artigo Científico ?

Engenheiro vs Cientista

“O engenheiro aprende para construir”

“O Cientista constrói para aprender”

Matriz de P&D

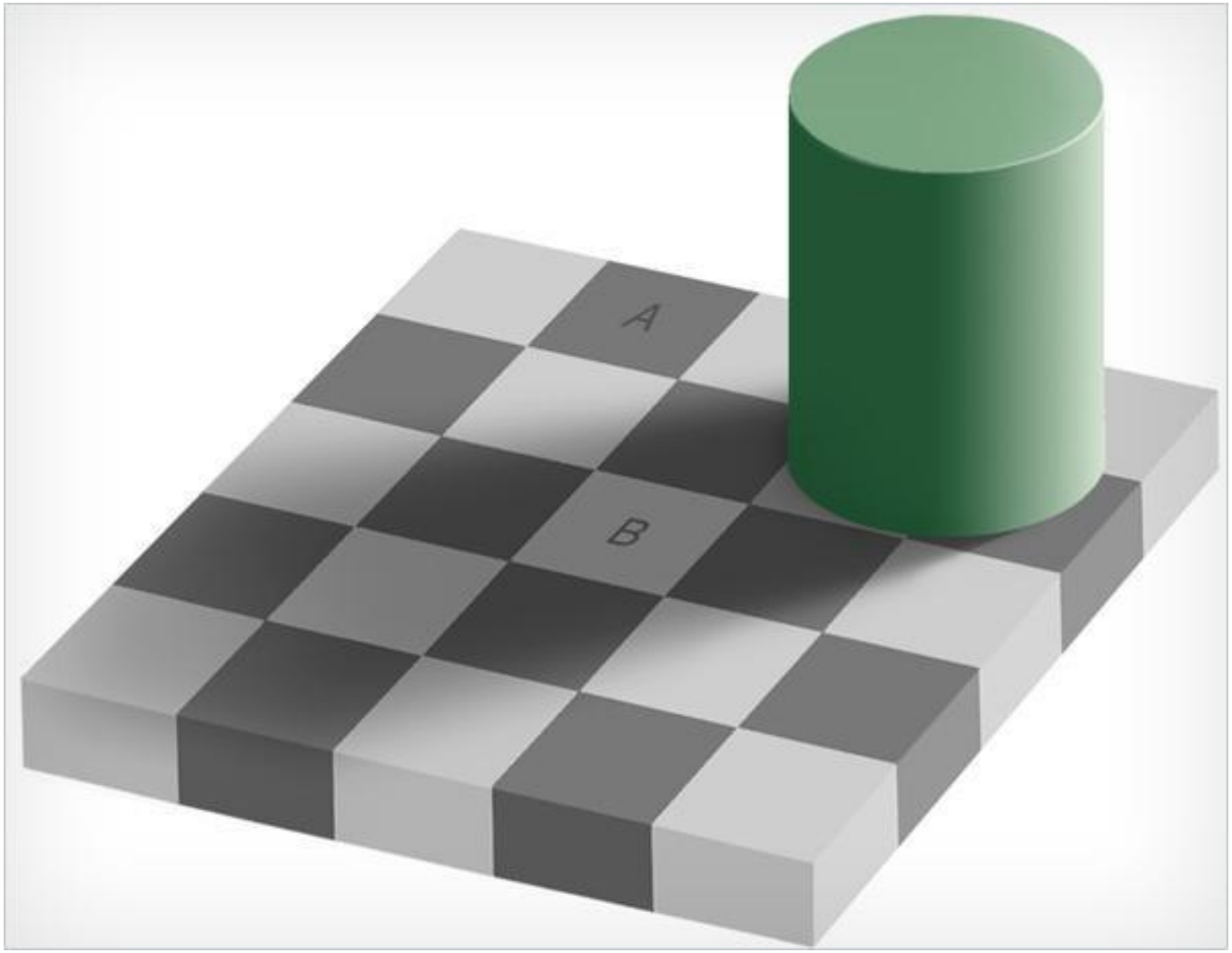

Problema
Conhecido
Não é bem conhecido
Engenharia (inovação)
Engenharia (incremental)
Pesquisa científica
Engenharia (inovação)
Não é bem conhecido
Conhecido
Solução

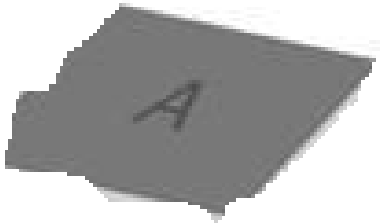
Antes de prosseguir,

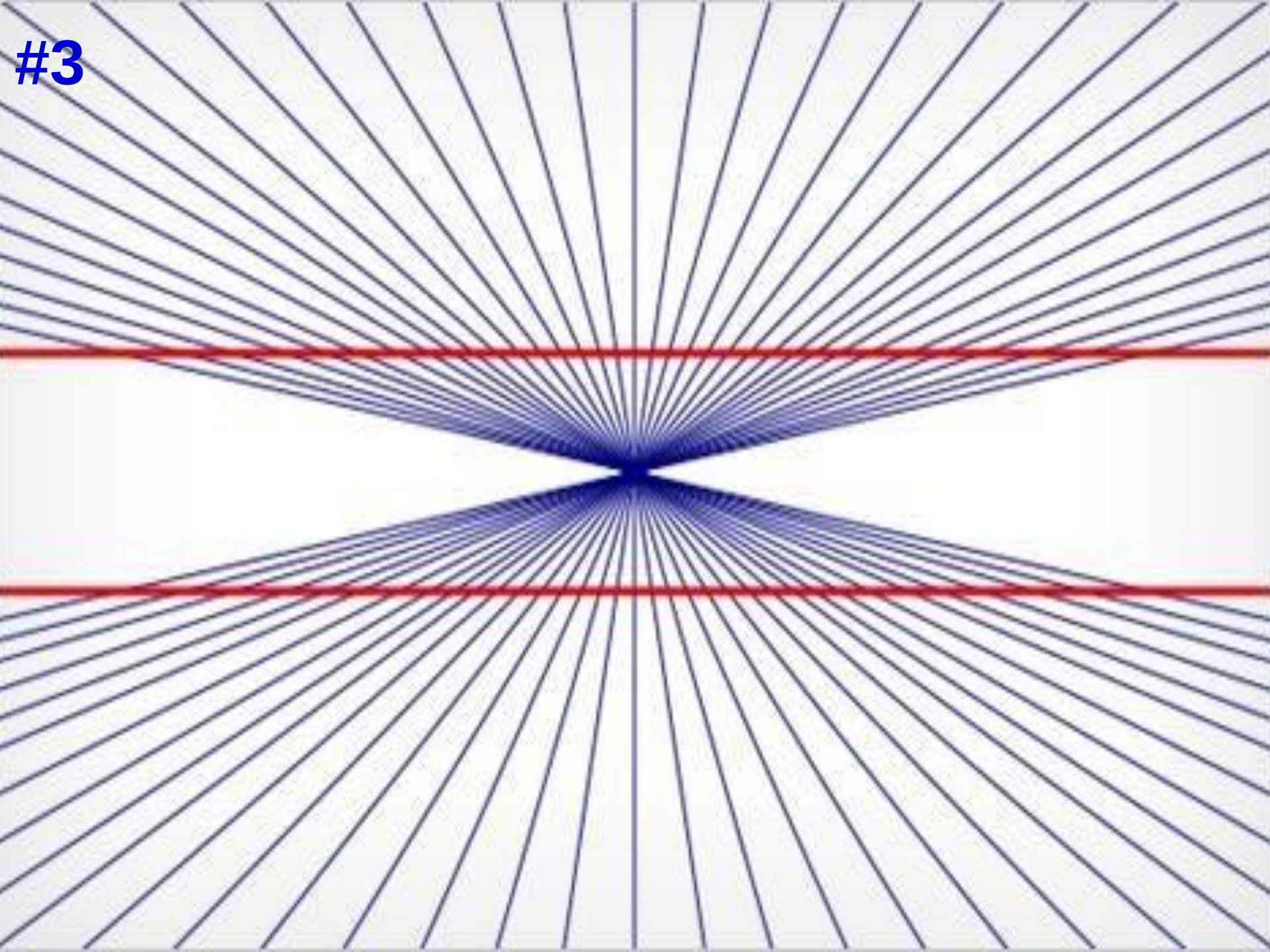
Vamos dar uma olhada no comportamento de nossa mente.

#1

#2



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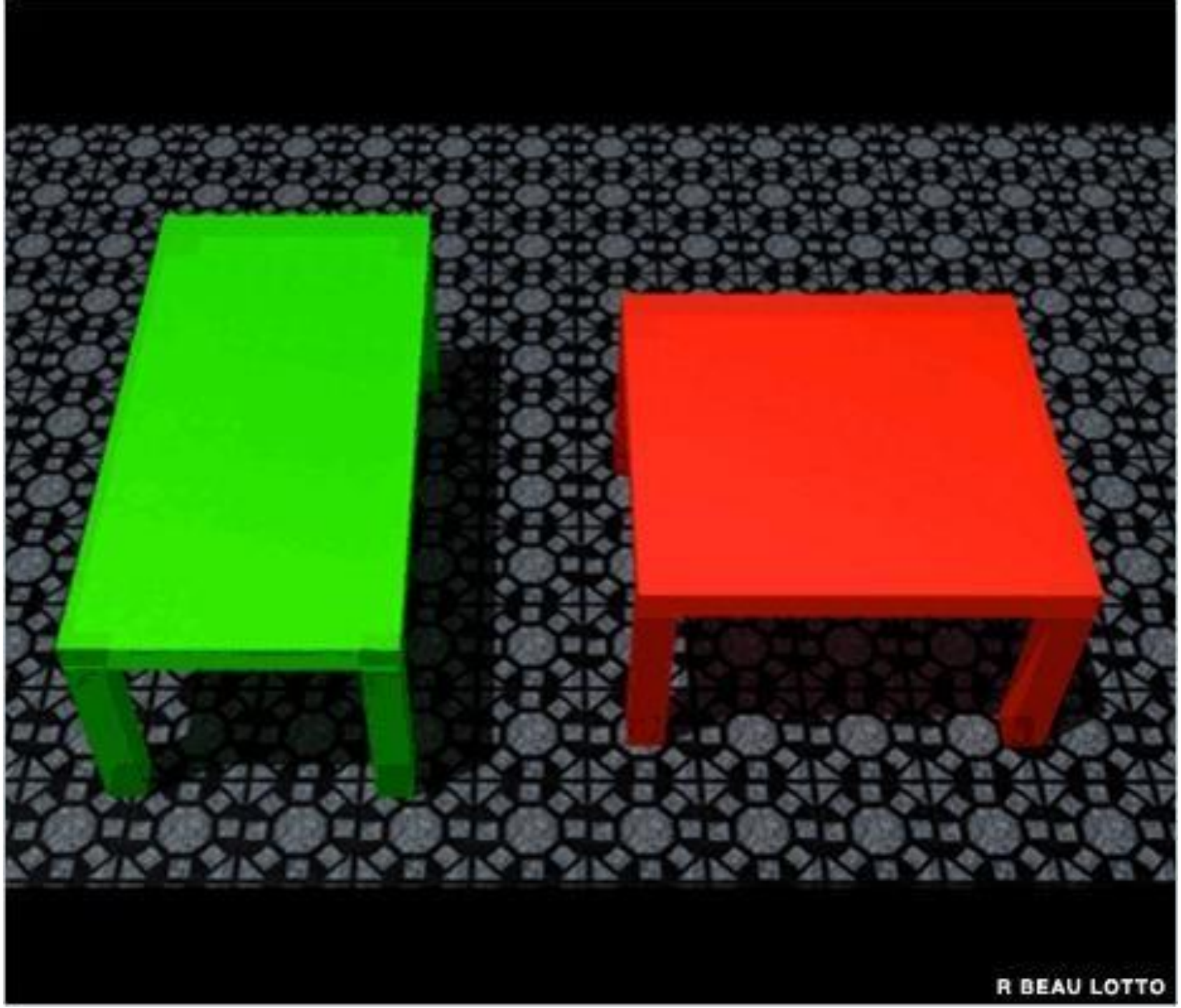

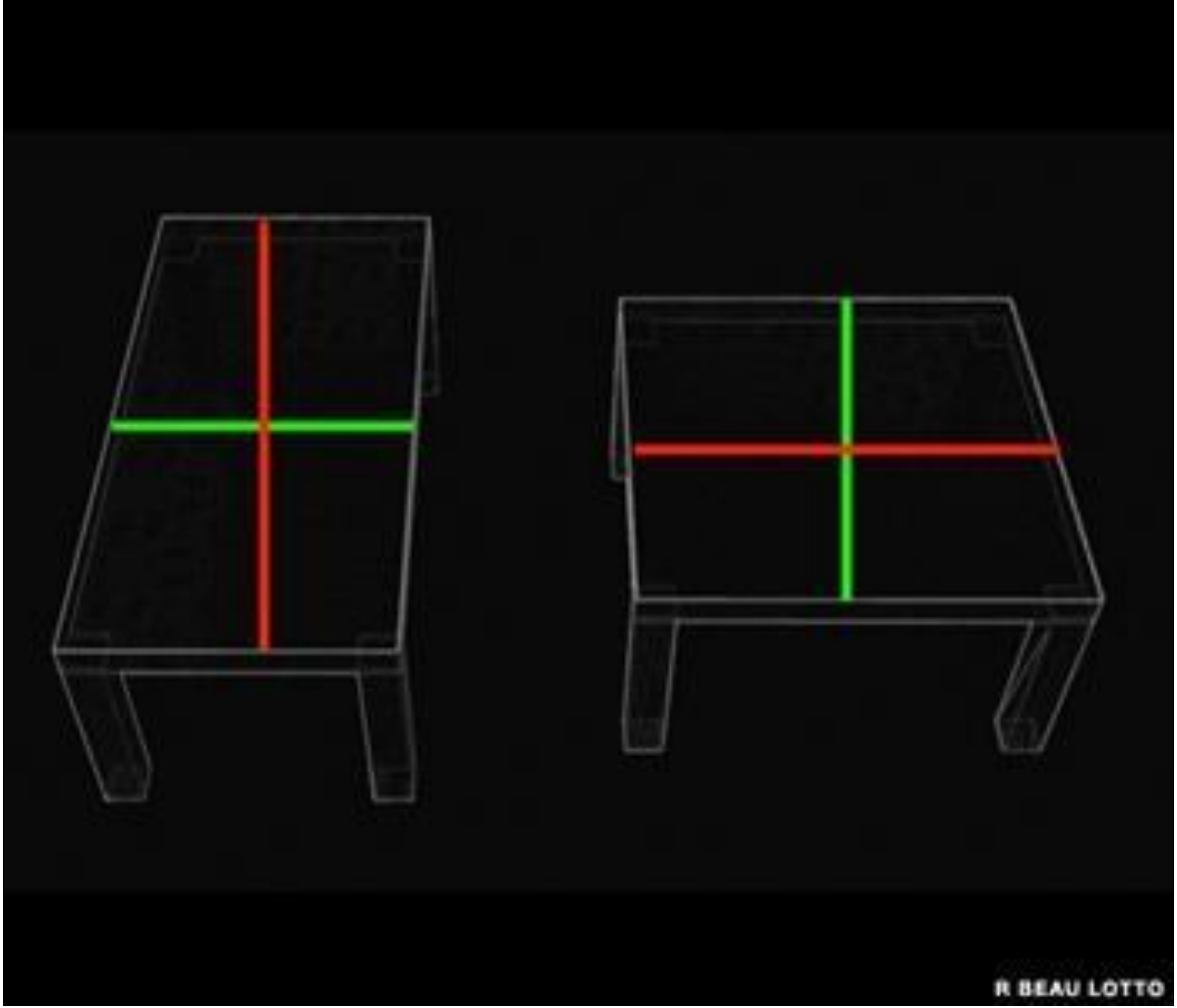
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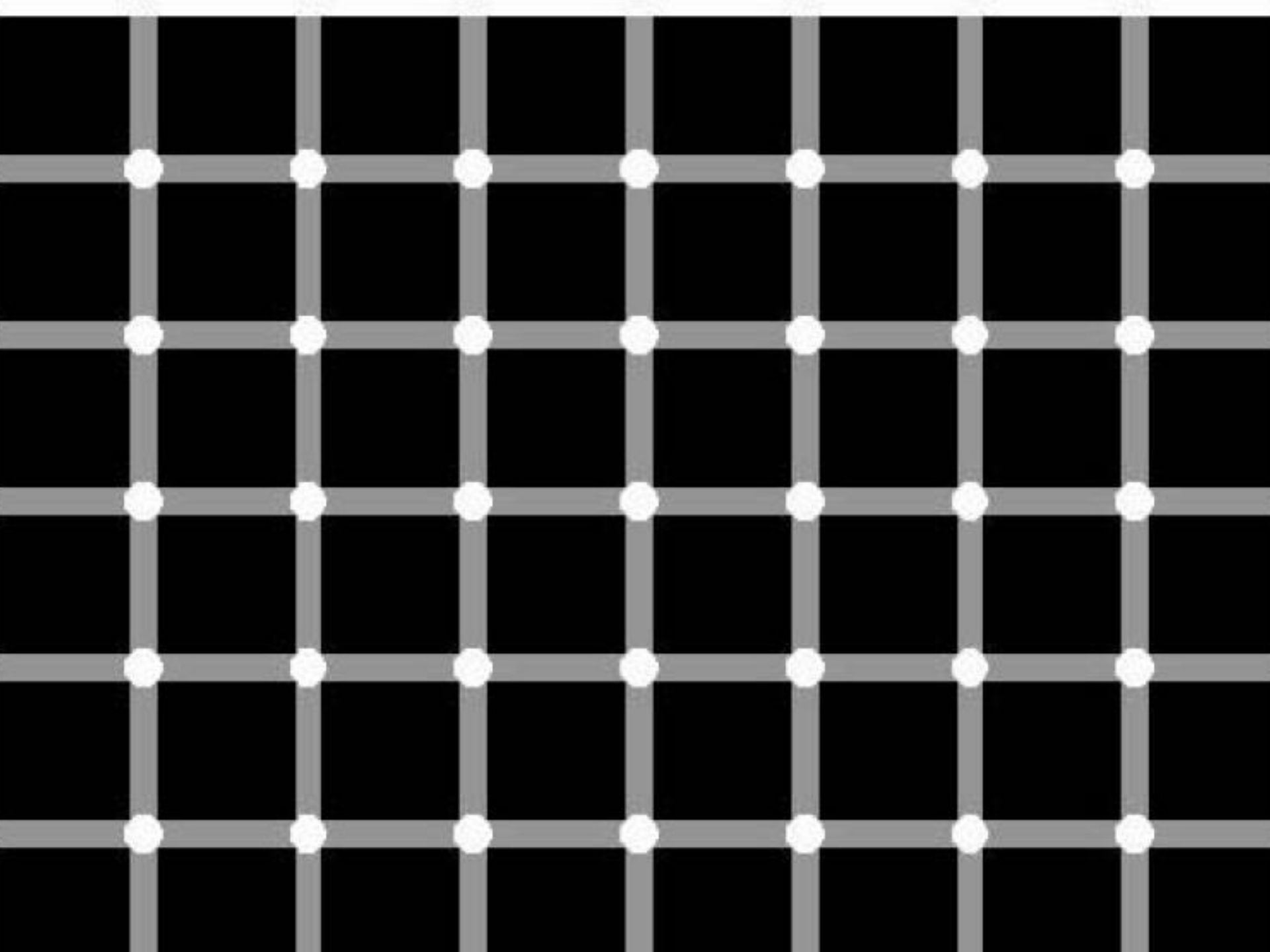
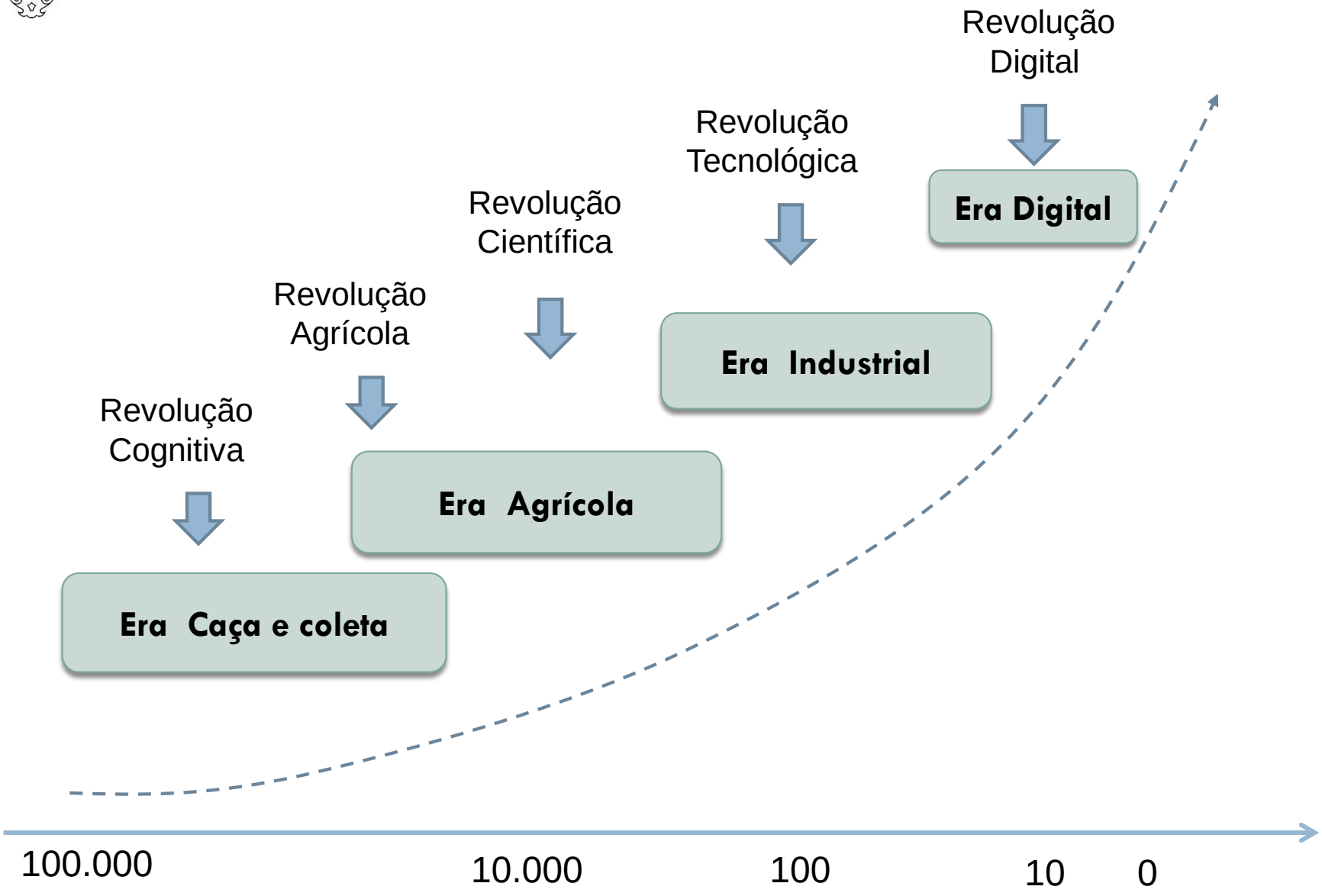


1. **Porque** fazer Pesquisa Científica ?

Evolução humana



Por que fazemos Pesquisa Científica ?

- A ciência é o motor da prosperidade.
- O crescimeto econômico do mundo é resultado de pesquisas básicas.
- A energia, os carros, smartphones, os alimentos são frutos de pesquisas.
- A sustentabilidade e a sobreviência depende de pesquisas.

2. **O que** é uma Pesquisa Científica ?

Pesquisa Científica é a atividade de aquisição de novos conhecimentos baseado no Método Científico.

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O que é o “Conhecimento” ?

É o conjunto: “Pergunta e Resposta”

Exemplo:

Pergunta: por que um objeto ao ser solto cái? Ou também, por que a Lua gira em torno da Terra?

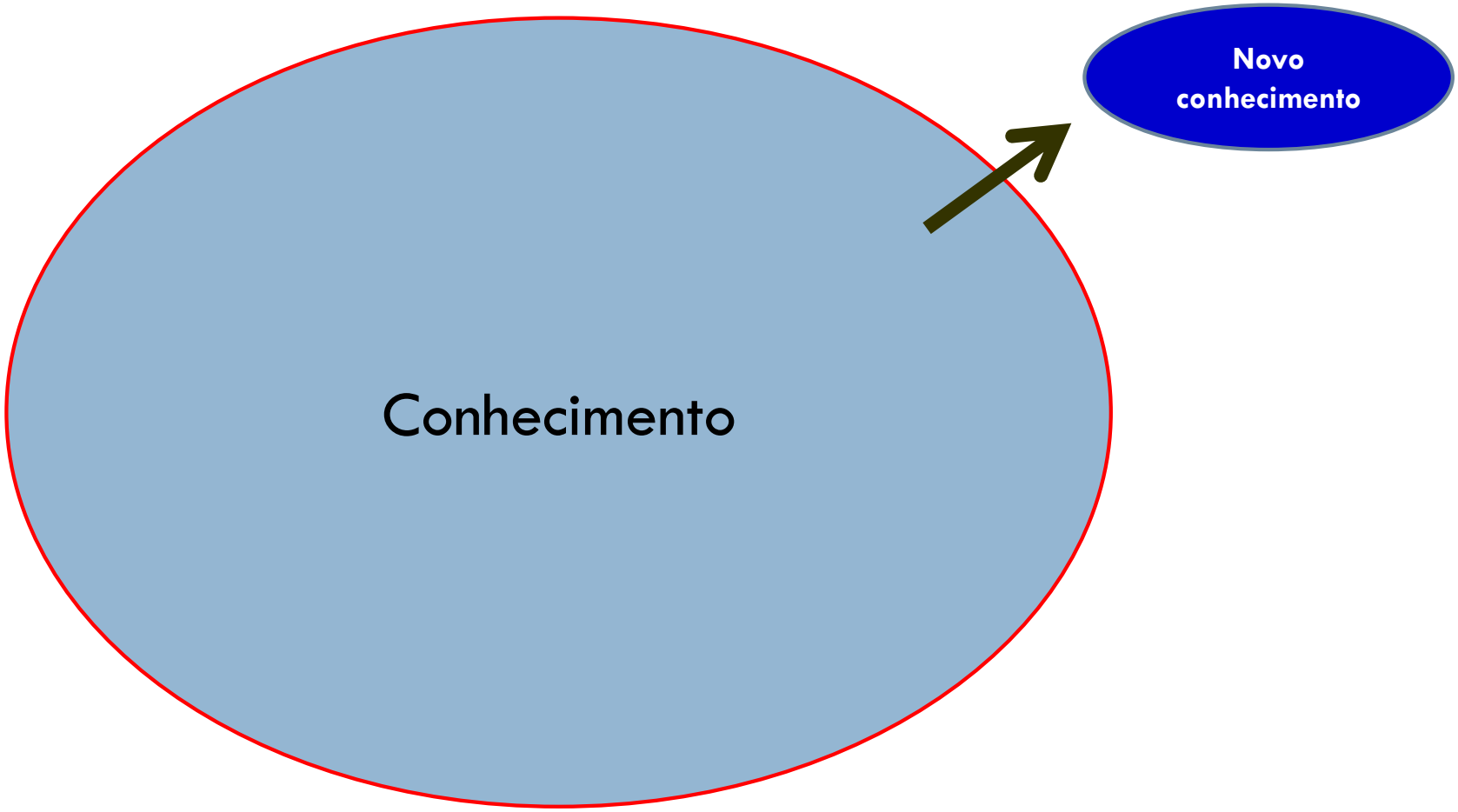
Resposta: existe um campo gravitacional que produz uma força no objeto, movendo-o em direção à Terra. (**Teoria do campo gravitacional de Newton**)

Pergunta e Resposta

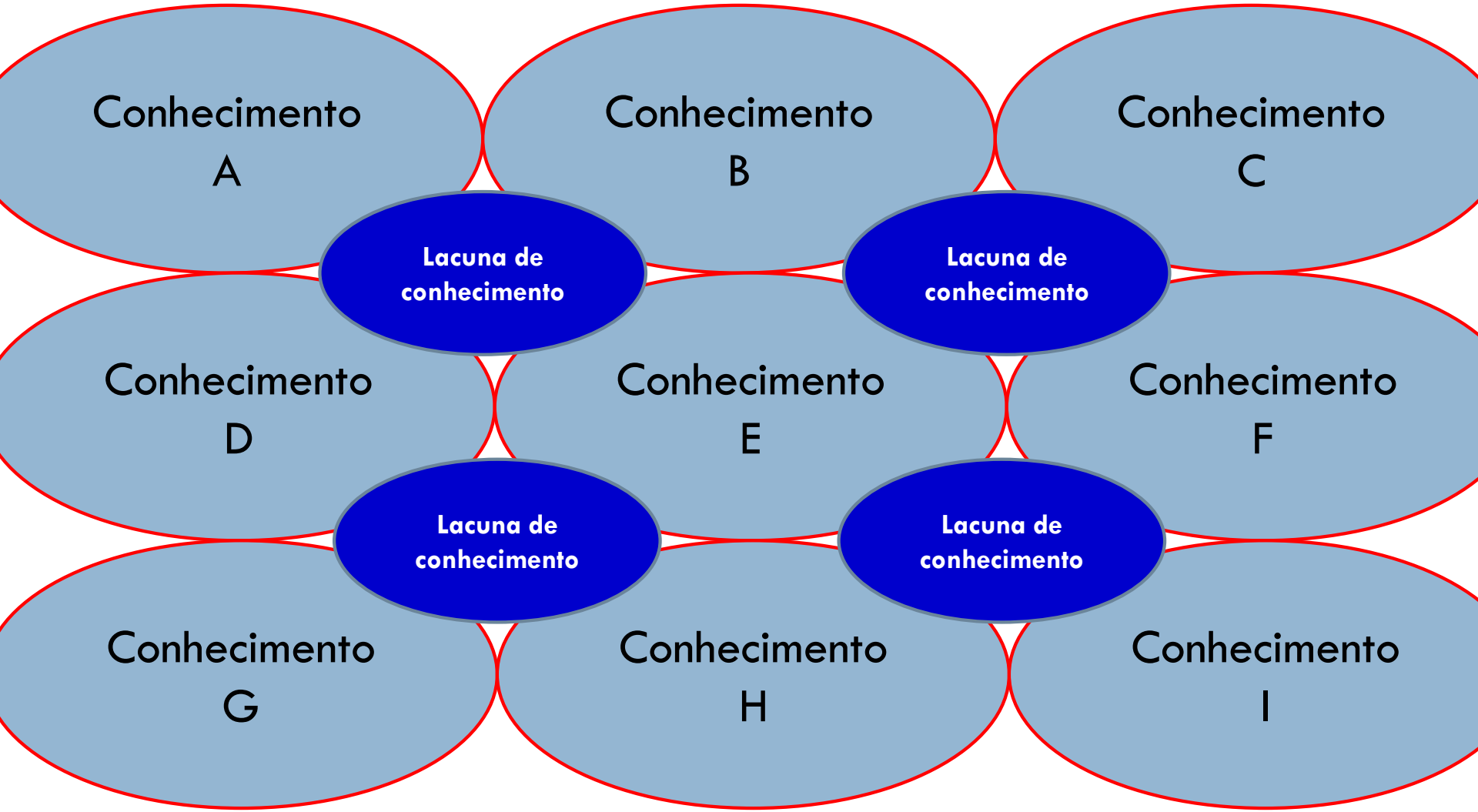
Resposta  **Passado**

Pergunta  **Futuro**

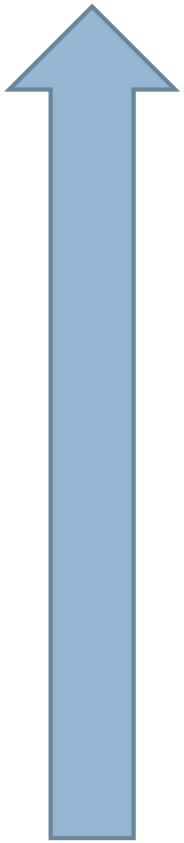
O que é a “Fronteira do Conhecimento” ?



O que é a “Lacuna de Conhecimento” ?



Hierarquia do conhecimento científico



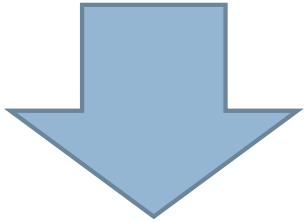
- **Leis** (elevado grau de confiabilidade e robustez)
- **Teoria** (previsão e ações de controle)
- **Modelos** (estrutura lógica ou matemática)
- **Experimentações** (observações, fatos)
- **Hipóteses** (especulações, ideias)

O que é o Método Científico ?

É o processo sistemático de investigação de um fenômeno.

- A execução segue etapas ordenadas.

3. **Como** realizar uma Pesquisa Científica ?



Aplicar a Metodologia Científica

Metodologia Científica

1) Qual necessidade/problema ? (lacuna)
2) Qual é o estado da arte? (literatura)
3) Quais são as propostas? (método)
4) Como vou testar ? (experimentação)
5) Avaliar os resultados (discussão)
6) Analisar as consequências (conclusão)
7) Compilar e Publicar (artigo, tese)

Identificar Necessidade

- Condição que causa incômodo;
  - Lacuna;

- Exemplo:
  - Reduzir o congestionamento (filas)
  - Estimar tempo de viagem
  - Reduzir acidentes

Identificar o Problema

- Quais são os problemas que conduzem para a necessidade?

- Exemplo:
  - Demanda de usuários
  - Oferta de TP
  - Excesso de veículos
  - Interrupção de fluxo
  - Rede de transporte desorganizada

Pesquisar a Literatura

- O que já foi feito para solucionar esses problemas ?

- Exemplos:
  - Metro: NY, Londres, Tokyo, Paris etc
  - Semaforização inteligente: NY, Londres
  - Inter-vehicle communic.
  - Guiagem Automática

Definir Hipóteses e variáveis

- Proposta de um método, técnica, ferramenta, processo, sistema para atacar o problema escolhido.

- Exemplo:
  - “Oferta de TP”
    - ✓ Aumentar a capacidade de transporte de um BRT através do emprego da tecnologia de Guiagem Automática.
  - Variáveis: B, v, d, D, tp

Implementar

- Modelos:
  - Matemáticos;
  - Computacionais;
  - Realístico;
  - Protótipo;
- Ambiente de testes

- Exemplo:
  - Modelo dinâmico do veículo – equações de estado;
  - Controle – simulação com MatLab;
  - Hardware e software
  - Pista de testes.

Experimentar

- Testar a hipótese através de:
  - Demonstração matemática;
  - Simulação computacional;
  - Ensaios de Laboratório;
  - Teste de campo;

- Exemplo:
  - Medição de precisão de acostamento nas paradas;
  - Medição de precisão de guiagem ao longo do corredor.
  - Variáveis: B, v, d, D, tp

Estudo de Caso

Um Estudo de Caso é uma pesquisa empírica que:

- Investiga um fenômeno contemporâneo dentro de seu contexto real;
- As fronteiras entre o fenômeno e o contexto não são claramente evidentes;
- Múltiplas fontes de evidências são utilizadas.

Aplicações do Estudo de Caso:

- Explicar ligações causais em intervenções ou situações da vida real que são complexas demais para tratamento através de estratégias experimentais ou de levantamento de dados;
- Descrever um contexto de vida real no qual uma intervenção ocorreu;
- Avaliar uma intervenção em curso e modificá-la com base em um Estudo de Caso ilustrativo;
- Explorar aquelas situações nas quais a intervenção não tem clareza no conjunto de resultados.

Avaliar os resultados

- Avaliar se os resultados confirmam (ou não) as hipóteses;

- Exemplo:
  - Precisão de acostamento na parada: 1 cm;
  - Precisão de guiagem ao longo do corredor: 5 cm
  - Redução de tempo de embarque / desembarque de 3s para 1s
  - Aumento de capacidade em 30%

Análisar as consequências

- Discutir as implicações dos resultados em relação ao problema.

- Exemplo:
  - Aumento de acessibilidade para usuários com deficiências, crianças e idosos
  - Possibilidade de eliminação de rampas de acessos para cadeirantes
  - Possibilidade de operação em vias estreitas – viabiliza implantação de faixas exclusivas em centros urbanos

Publicar

Os resultados da pesquisa devem ser compilados em forma de:

- Dissertação
- Tese
- Artigos

Estrutura de um Artigo

- Título
- Autores
- Resumo
- Palavras-chave
- 1. Introdução
- 2. Embasamento teórico / estado-de-arte
- 3. Métodos
- 4. Demonstração Analítica / Simulação / Experimentação
- 5. Resultados / Discussão
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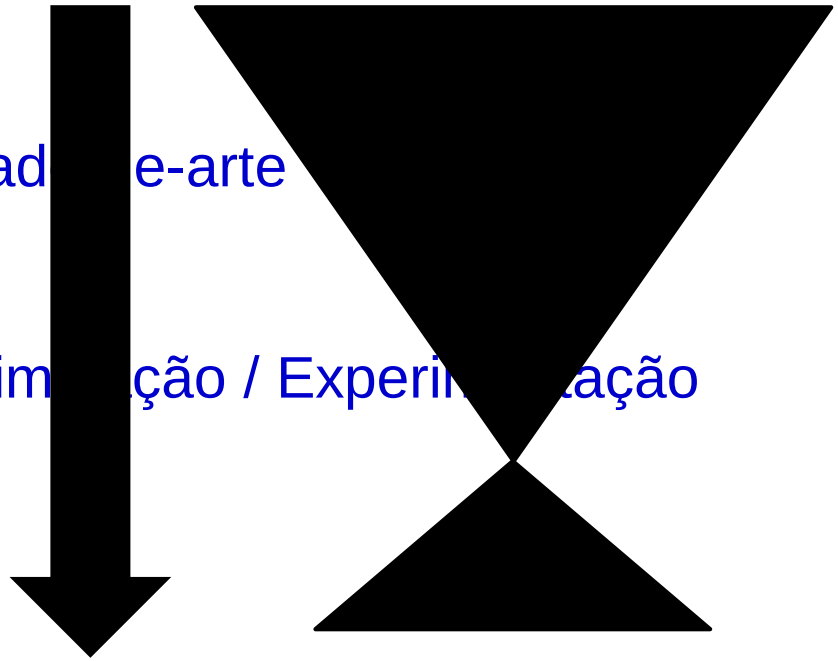

Resumo

- Contextualização
- Gap (lacuna)
- Objetivo
- Métodos
- Demonstração, Simulação ou Experimentação
- Resultados
- Discussão
- Conclusão

Wu, CH, 2004 **Travel-time prediction with support vector regression**

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Travel time is a fundamental measure in transportation. Accurate travel-time prediction also is crucial to the development of intelligent transportation systems and advanced traveler information systems. In this paper, we apply support vector regression (SVR) for travel-time prediction and compare its results to other baseline travel-time prediction methods using real highway traffic data. Since support vector machines have greater generalization ability and guarantee global minima for given training data, it is believed that SVR will perform well for time series analysis. Compared to other baseline predictors, our results show that the SVR predictor can significantly reduce both relative mean errors and root-mean-squared errors of predicted travel times. We demonstrate the feasibility of applying SVR in travel-time prediction and prove that SVR is applicable and performs well for traffic data analysis.

(207 citações)

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OBJETIVO / MÉTODO

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HIPÓTESE

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RESULTADO

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CONCLUSÃO

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The capability to forecast traffic volume in an operational setting has been identified as a critical need for intelligent transportation systems (ITS). In particular, traffic volume forecasts will support proactive, dynamic traffic control. However, previous attempts to develop traffic volume forecasting models have met with limited success. This research effort focused on developing traffic volume forecasting models for two sites on Northern Virginia's Capital Beltway. Four models were developed and tested for the freeway traffic flow forecasting problem, which is defined as estimating traffic flow 15 min into the future. They were the historical average, time-series, neural network, and nonparametric regression models. The nonparametric regression model significantly outperformed the other models. A Wilcoxon signed-rank test revealed that the nonparametric regression model experienced significantly lower errors than the other models. In addition, the nonparametric regression model was easy to implement, and proved to be portable, performing well at two distinct sites. Based on its success, research is ongoing to refine the nonparametric regression model and to extend it to produce multiple interval forecasts.

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RESULTADO / DISCUSSÃO

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CONCLUSÃO

Introdução

- Contextualizar o problema
- Apresentar o objetivo da pesquisa
- Justificar por que a pesquisa é relevante
- Conceber um argumento lógico com premissas e conclusões.
- A conclusão do argumento é o nosso objetivo
- Eliminar premissas desnecessárias, mas não pode faltar as premissas necessárias.
- Perguntar: a informação é necessária para o leitor entender e aceitar a plausibilidade do objetivo ?

Método

- As conclusões são tirados de uma base empírica (resultados de observação ou experimentação)
- As bases empíricas devem ser universais, ou seja deve-se apresentar o Método que dê a outros cientistas o caminho para encontrarem as mesmas bases empíricas do trabalho.
- O método pode ser dedutivo ou indutivo.
- O método é o conjunto de procedimentos realizados na pesquisa.

Método – Divisão Lógica

- **Sujeito da pesquisa:** elementos que foram investigados
- **Delineamento do estudo**: estratégia e plano de ação para consumar a pesquisa.
- **Procedimentos específicos**: é a “receita de bolo de como o estudo foi montado, incluindo como as variáveis foram consideradas e registradas”.
- **Análise dos resultados**: ferramentas utilizadas para analisar os resultados (estatística, testes, cálculos)

Resultados

- **Eliminar** dados que negam as conclusões
- **Mudar** a conclusão em função dos dados
- **Incluir** apenas os resultados relevantes para as suas conclusões
- **5 formas**: descrição no texto, tabelas, gráficos, esquemas, fotos ou desenhos
- **3 critérios**: lógico, ênfase e foco.

Discussão e Conclusão

- Usar as evidências (métodos e resultados), acrescidas de informações da literatura, para defender as suas conclusões.
- Iniciar sintetizando o fim de sua história (as suas principais conclusões – desvendar o mistério).
- Argumentar (defender) cada uma das conclusões baseado em tabelas, gráficos ou figuras.
- Mostrar a ligação das suas conclusões com o contexto mais geral da ciência atual (Generalização)

Referências

1) Jung, 2014 – Artigos Científicos: Análise e Elaboração:

http://pt.slideshare.net/profjung/artigos-cientficos-concepo-e-elaboro-v-2014

e-Disciplinas/ PTR2917/Aula 2/Guia de Escrita Científica:

2) Guia para Escrita Científica

3) Day, R., 1998 – How to Write & Publish a Scientific Paper