

Mensch-Maschine-Interaktion

M. Eng. Elektrotechnik

Klausur vom 6. Februar 2025: Beispiellösungen

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Lösungen von DeekSeek R1. In Rot kommentiert von Jörn Loviscach.

Gedanken

Okay, let's tackle these questions one by one. I need to make sure I understand each one properly and provide accurate answers. Let's start with the first one about inverting grayscale values for perceptual uniformity.

****1. Grayscale Inversion:**** The question is about which curve (A, B, C) to use so that a linear perceptual gradient from black to white becomes white to black. I remember that human perception of lightness isn't linear with physical intensity. The standard approach involves gamma correction, usually using a power function. The inverse should be the complement in a perceptually uniform space. The sRGB standard uses a gamma of about 2.2. So inverting might involve taking the reciprocal gamma. If the original is linear (gamma 1), then to invert perceptually, we need to apply gamma correction. Wait, maybe the curves are different. Curve B is linear (1-x), which just inverts the physical intensity but doesn't account for perception. Curve C looks like a quarter-circle ($\sqrt{1-x^2}$), which might not be right. Curve A is $(1-\sqrt{x})^2$. Hmm. Wait, the correct inverse in perceptual terms would involve applying the inverse gamma. If the original is gamma-encoded, then the inverse would be taking the power to reverse it. For example, if the display has a gamma of 2.2, to invert perceptually, you might use a gamma of 1/2.2. But the options here are given as three curves. The correct answer is probably the one that applies a gamma correction. If the original is linear (gamma 1), then to make it perceptually uniform, you apply gamma 2.2. But since we need to invert it, maybe it's $(1 - x^{1/2.2})$ or something. Alternatively, maybe the correct curve is the one that's a power function. Looking at the curves: Curve A is $(1-\sqrt{x})^2$, which simplifies to $1 - 2\sqrt{x} + x$. Not a standard gamma. Curve C is $\sqrt{1-x^2}$, which is a circle quadrant. Curve B is linear. But perceptually, the inverse

should be non-linear. The standard way is to take the inverse in a perceptually uniform space. For example, if the original is sRGB (gamma 2.2), then the inverse would apply the inverse gamma. Wait, but the question says the grayscale values are proportional to physical intensity (linear), and we need to invert them so that the perceptual gradient is reversed. So to go from linear to perceptual inverse, we need to apply gamma correction. So the original is linear (gamma 1), and to make it perceptually uniform when inverted, we should apply gamma correction. So the inversion would be to take the linear value, apply gamma to get perceptual, invert, then apply inverse gamma. Wait, maybe it's simpler: if the original mapping is physical intensity (linear) to display, which is gamma-encoded. To invert the perceptual gradient, you need to take the gamma-encoded value, invert it (1 - value), then apply the inverse gamma. Wait, this is getting confusing. Let me think again. The key is that the grayscale values are proportional to physical intensity (so linear), but human perception is non-linear. So a linear gradient from black to white is not perceived as uniform. To make a perceptually uniform gradient, you need to apply a gamma correction (e.g., gamma 2.2). If we want to invert the gradient perceptually, we need to take the gamma-corrected value, invert it (1 - value), and then maybe linearize it again? Or perhaps the correct approach is to take the original linear value, invert it in the perceptual space. So the steps would be: physical intensity (linear) → convert to perceptual (apply gamma), invert (1 - perceptual value), then convert back to physical intensity (apply inverse gamma). So the curve would be $(1 - x^{\text{gamma}})^{1/\text{gamma}}$. For gamma=2.2, this would be $(1 - x^{2.2})^{1/2.2}$. But none of the given curves look exactly like that. Alternatively, maybe the problem is simpler: the standard inversion in perceptual space is to take the gamma-corrected value and invert it. So if the original is gamma-encoded, then the inverse is 1 - gamma-encoded value. But the question states that the original grayscale is linear (proportional to physical intensity). So to make a perceptually uniform inversion, the curve should first apply gamma to linearize perception, invert, then apply inverse gamma? Hmm. Alternatively, maybe the correct answer is curve C, which is $\sqrt{1 - x^2}$. But that's a quarter-circle. Alternatively, curve A is $(1 - \sqrt{x})^2$. Let's see: if x is the original linear value, then to invert perceptually, we might need to apply a power function. For example, if the display uses a gamma of 2.2, the perceived lightness L is proportional to $x^{1/2.2}$. To invert, we want 1 - L, which would be $1 - x^{1/2.2}$. But to represent this as a physical intensity, we need to apply the inverse gamma, so $(1 - x^{1/2.2})^{2.2}$. That's a complicated function. But none of the given curves match this. Alternatively, perhaps the correct inversion is to use the sRGB transfer function. Wait, maybe the correct answer is curve C, which is $\sqrt{1 - x^2}$, but that doesn't seem right. Alternatively, the correct inversion is $1 - x^{1/2.2}$, but without the inverse gamma. Wait, I'm getting stuck here. Let me think of the standard gamma curves. If the original is linear (gamma 1), and we want to invert it perceptually, we need to apply gamma correction first, invert, then linearize. Wait, no. The display already applies gamma correction. So if the image is stored as linear values, but when displayed, they are gamma-encoded. So to create a perceptually uniform gradient from black to white, the image should have values with gamma applied. So if the original image is linear, but we want the perceptual inverse, we need to apply gamma to the linear value, invert it (1 - gamma_corrected), and then maybe that's it. But the question is about transforming the grayscale values so that when displayed, the

perceptual gradient is inverted. So the transformation would be: $\text{new_value} = 1 - (\text{original_value})^{1/\gamma}$. Then, when displayed, the gamma is applied, so $(\text{new_value})^\gamma = (1 - \text{original_value}^{1/\gamma})^\gamma$. Hmm, not sure. Alternatively, maybe the correct answer is to use the inverse in the perceptual space, which would be a power function. For example, if the original is x , the inverted value would be $(1 - x^\gamma)^{1/\gamma}$. But I'm not sure. Alternatively, the correct answer is the curve that is the inverse in the gamma-corrected space. So if the original is linear, to invert perceptually, you apply gamma, invert, then apply inverse gamma. So the function would be $(1 - x^\gamma)^{1/\gamma}$. For $\gamma=2.2$, that's a complicated function. But looking at the given curves: Curve A is $(1 - \sqrt{x})^2$. Let's see: If gamma is 0.5, then $x^{0.5}$ is \sqrt{x} , so $1 - \sqrt{x}$, then squared would be $(1 - \sqrt{x})^2$. That's similar to gamma 0.5, but not sure. Alternatively, if gamma is 2, then $(1 - x^{0.5})^2$. Hmm. Maybe the correct curve is A, which applies a square after subtracting \sqrt{x} . But I'm not entirely confident. Alternatively, the standard way to invert a gamma-corrected image is to use $1 - x$. But that's curve B, which is linear. However, that would not account for perceptual uniformity. So perhaps the correct answer is curve C, which is $\sqrt{1 - x^2}$, but that's a quarter-circle. Wait, maybe the answer is curve C, which is the inverse in the sense of the CIELAB lightness or something. Alternatively, considering that the human perception is roughly a power function, so to invert, you take the complement in the perceptual space. If the original is linear, then perceptual lightness is $x^{1/3}$ or similar. The inverse would be $(1 - x^{1/3})^3$. That might look like curve A or C. Hmm. I'm a bit stuck here, but I think the correct answer is curve C, which is the quarter-circle, but I'm not sure. Wait, no. Wait, another approach: The problem states that the original grayscale is proportional to physical intensity (linear), and we need to invert it so that the perceptual gradient is reversed. To achieve this, we need to apply a gamma correction to linearize the perception, invert, then apply the inverse gamma. So the transformation would be: $\text{inverted_value} = 1 - (\text{original_value})^\gamma$, then apply the inverse gamma: $(\text{inverted_value})^{1/\gamma}$. But this might not be necessary. Alternatively, the correct inversion is to take the original linear value, apply the inverse gamma to get perceptual value, invert it ($1 - \text{perceptual}$), then apply gamma to get back to physical. So: $(1 - x^{1/\gamma})^\gamma$. For $\gamma=2.2$, this would be $(1 - x^{0.4545})^{2.2}$. This function would have a shape that starts at 1 when $x=0$, decreases slowly at first, then more rapidly. Comparing to the given curves: Curve A is $(1 - \sqrt{x})^2$. If gamma is 2, then $(1 - x^{1/2})^2$, which is exactly curve A. So if the gamma is 2, then curve A is correct. But in reality, gamma is around 2.2, but perhaps the question is simplified. So curve A would be the correct answer. Because if gamma is 2, then the inversion would be $(1 - \sqrt{x})^2$, which is curve A. Therefore, the answer is curve A. But wait, the labels in the plot are: Curve C is labeled as C at $(0.7, \sqrt{1-0.7^2}) \approx 0.7$. Wait, $\sqrt{1 - 0.49} = \sqrt{0.51} \approx 0.71$, so the label C is on the $\sqrt{1 - x^2}$ curve. Curve A is labeled at $x=0.1, y=(1 - \sqrt{0.1})^2 \approx (1 - 0.316)^2 \approx (0.684)^2 \approx 0.467$. So curve A is $(1 - \sqrt{x})^2$. If gamma is 2, then the perceptual inversion would be $(1 - x^{1/2})^2$, which is exactly curve A. Therefore, the correct answer is curve A. So the answer is curve A, which is labeled as C in the plot? Wait, no. Wait, the description says: Kurve C: $y = (1 - \sqrt{x})^2$. Wait, no. Wait, the user wrote:

Kurve A: $y = \sqrt{1-x^2}$

Kurve B: $y = 1 - x$

Kurve C: $y = (1 - \sqrt{x})^2$

Wait, the labels in the plot are:

- Curve A is labeled as C at $(0.7, \sqrt{1-0.7^2})$ which is $\sqrt{1 - 0.49} = \sqrt{0.51} \approx 0.71$. So curve A is $\sqrt{1 - x^2}$, labeled as C.

Wait, no. The user's code says:

For Kurve A: they plot $\sqrt{1-x^2}$ and label it as C.

Wait, looking at the code:

```
\addplot ... sqrt(1-x^2);
```

```
\node ... at (0.7, sqrt(1-0.7^2)) C;
```

So this curve is labeled as C. Then:

Wait, the labels in the plot are:

- The $\sqrt{1 - x^2}$ curve is labeled C.
- The $1 - x$ curve is labeled B.
- The $(1 - \sqrt{x})^2$ curve is labeled A.

So the actual curves are:

C: $\sqrt{1 - x^2}$

B: $1 - x$

A: $(1 - \sqrt{x})^2$

But according to the problem statement, the three curves are A, B, C, but in the code, they're labeled as C, B, A. That's confusing. Wait, the user wrote:

Kurve A: $y = \sqrt{1-x^2}$, solide Linie

Kurve B: $y = 1 - x$, gestrichelte Linie

Kurve C: $y = (1 - \sqrt{x})^2$, gepunktete Linie

But in the code, when plotting, Kurve A is plotted with label C, Kurve B with label B, and Kurve C with label A. That's a mistake in the code, but perhaps in the actual figure, the labels are correct. But assuming that the labels in the figure are correct as per the code, then:

- The curve with equation $y = \sqrt{1 - x^2}$ is labeled C.
- The linear curve $y = 1 - x$ is labeled B.
- The curve $y = (1 - \sqrt{x})^2$ is labeled A.

But according to the problem statement, the question is which of the three curves (A, B, C) to use. So if the correct transformation is $(1 - \sqrt{x})^2$, which is labeled as A in the plot, then the answer is curve A. But according to my earlier reasoning, if gamma is 2, then the inversion would be $(1 - x^{(1/2)})^2$, which is exactly curve A. Therefore, the correct answer is curve A.

****Answer 1:**** Die Kurve A ist zu verwenden. Da die menschliche Wahrnehmung von Helligkeit nicht linear zur physikalischen Intensität verläuft, sondern annähernd einer Potenzfunktion folgt (Gamma-Korrektur), muss die Umkehrfunktion dies kompensieren. Die Kurve A, definiert durch $y = (1 - \sqrt{x})^2$, entspricht der Anwendung einer Gamma-Korrektur mit anschließender linearen Inversion, wodurch ein wahrnehmungsmäßig gleichmäßiger Verlauf von Weiß nach Schwarz entsteht. Die lineare Kurve B würde nur die physikalische Intensität invertieren, nicht aber die Wahrnehmung berücksichtigen. Kurve C ($\sqrt{1 - x^2}$) bildet keine standardkonforme Gamma-Inversion ab.

****2. Events in der Anwendung:**** Das Programm muss verschiedene Event-Typen verarbeiten:

1. ****Timer-Event:**** Jede Minute neue Daten hinzufügen. Verarbeitung: Datenbankabfrage, Anhängen an Zeitreihe, UI-Update.
2. ****Mouse-Move-Event:**** Über der Kurve zeigt Tooltip mit Werten. Verarbeitung: Koordinatenabgleich mit Datenpunkten, Tooltip-Positionierung.
3. ****Radio-Button-Change-Event:**** Auswahl der anzuzeigenden Kurve. Verarbeitung: Datenquelle wechseln, Grafik neu rendern.
4. ****Slider-Change-Event:**** Zoom-Faktor anpassen. Verarbeitung: Skalierung der Achsen, Neudarstellung.
5. ****Paint-Event:**** Zeichnen der Kurve bei Größenänderung. Verarbeitung: Neuberechnung der Darstellung basierend auf aktuellen Parametern.

****3. Affordances-Trick:**** Der Trick nutzt die wahrgenommenen Affordances (angebotene Handlungsmöglichkeiten) des Mischpults. Die ungenutzten Regler bieten pseudofunktionale Bedienelemente, die keine tatsächliche Funktion haben, aber die Illusion von Kontrolle vermitteln. Dies entspricht einer bewussten Fehlleitung der Affordances, da die Regler scheinbar eine Funktion anbieten (Sound-Anpassung), aber keine reale Wirkung haben. Es reduziert kognitive Dissonanz bei Laien, die subjektiv eine Veränderung wahrnehmen, während objektiv keine stattfindet – ein klassisches Beispiel für manipulative Affordance-Designs.

****4. VR vs. Realität:****

1. ****Eingeschränktes Sichtfeld:**** Aktuelle VR-Brillen haben 110° vs. menschliche 180°
2. ****Verminderte Auflösung:**** Screen-Door-Effekt durch sichtbare Pixelstruktur
3. ****Fehlende Tiefenwahrnehmung:**** Parallaxe nur für binokulare Tiefe, keine Akkommodation

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4. **Eingeschränkte Haptik:** Keine echte taktile Rückmeldung bei Berührung
 5. **Latenzprobleme:** Verzögerung zwischen Kopfbewegung und Bildschirmaktualisierung

5. k-NN vs. Neuronale Netze:

1. **Datenmenge:** k-NN benötigt große Trainingsdaten im Betrieb, NN im Training
2. **Rechenaufwand:** k-NN rechenintensiv bei Vorhersage, NN bei Training
3. **Interpretierbarkeit:** k-NN durch Ähnlichkeitsabfrage nachvollziehbarer
4. **Nichtlineare Beziehungen:** NN kann komplexere Muster erfassen
5. **Feature-Engineering:** NN benötigt weniger manuelle Vorverarbeitung

6. ML im Verkehr:

1. **Ampelsteuerung optimieren** (Reinforcement Learning)
2. **Unfallrisiko vorhersagen** (Klassifikation)
3. **Verkehrsflussprognose** (Regression)
4. **Verkehrsmusterclusterung** (Clustering)
5. **Stauererkennung in Echtzeit** (Anomaliedetektion, Klassifikation)

7. Visualisierungsmethoden:

1. **Choroplethenkarte** (Verbrauch pro Unterbezirk)
2. **Zeitreihen-Clustering** (Heatmap/Matrix der Ähnlichkeiten)
3. **Bubble Chart auf Karte** (Größe=Verbrauch/Pers., Position=Geokoordinaten)
4. **Boxplots/Violinplots** pro Bezirk
5. **Scatterplot-Matrix** für multivariate Exploration

8. Animationen:

+ Positiv:

1. Führt Aufmerksamkeit (z.B. sanftes Hervorheben)
2. Vermittelt Zustandsübergänge verständlich
3. Verbessert räumliches Verständnis (z.B. Objektbewegung)

- Negativ:

1. Erhöhte kognitive Belastung bei Übernutzung
2. Verzögerte Interaktion durch Wartezeiten

9. Evaluationsmethoden:

-
1. **Think-Aloud:**
 - + Direkte Einblicke in Nutzungsprobleme
 - Künstliche Situation verfälscht Verhalten
 2. **Cognitive Walkthrough:**
 - + Systematische Fehleridentifikation
 - Keine echten Nutzerperspektiven
 3. **Eye-Tracking:**
 - + Objektive Blickverlaufsdaten
 - Teure Hardware erforderlich
 4. **Logfile-Analyse:**
 - + Große Datensätze automatisch auswertbar
 - Keine Ursachen für Fehler erkennbar
 5. **Fragebögen:**
 - + Standardisierte Vergleichbarkeit
 - Subjektive Einschätzungen, keine Objektivität

10. Statistische Tests:

1. **t-Test für gepaarte Stichproben** (vorher/nachher gleiche Gruppe)
2. **Chi-Quadrat-Anpassungstest** (beobachtete vs. erwartete Häufigkeiten)
3. **t-Test für unabhängige Stichproben** (zwei Gruppen)
4. **ANOVA** (Vergleich dreier Gruppen)
5. **Ein-Stichproben-t-Test** (Mittelwert vs. Referenzwert)

Lösungen

Aufgabe 1: Grauwertinversion

Die Kurve **A** ist zu verwenden. Da die menschliche Wahrnehmung von Helligkeit nicht linear zur physikalischen Intensität verläuft, sondern annähernd einer Potenzfunktion folgt (Gamma-Korrektur), muss die Umkehrungsfunktion dies kompensieren. Die Kurve **A**, definiert durch $y = (1 - \sqrt{x})^2$, entspricht der Anwendung einer Gamma-Korrektur mit anschließender linearer Inversion, wodurch ein wahrnehmungsmäßig gleichmäßiger Verlauf von Weiß nach Schwarz entsteht. Die lineare Kurve **B** würde nur die physikalische Intensität invertieren, nicht aber die

Wahrnehmung berücksichtigen. Kurve C ($\sqrt{1-x^2}$) bildet keine standardkonforme Gamma-Inversion ab.

Aufgabe 2: Event-Verarbeitung

1. **Timer-Event:** Minütliches Hinzufügen neuer Daten (Datenbankabfrage, UI-Update)
2. **Mouse-Move-Event:** Tooltip-Anzeige (Koordinatenabgleich, Datenpunkte ermitteln)
3. **Radio-Button-Change:** Kurvenauswahl (Datenquelle wechseln, Grafik aktualisieren)
4. **Slider-Change:** Zoom-Anpassung (Achsenskalierung neu berechnen)
5. **Paint-Event:** Neuzeichnen bei Größenänderung (Darstellungslogik neu ausführen)

Aufgabe 3: Affordances-Trick

Der Trick nutzt die Diskrepanz zwischen realen und wahrgenommenen Affordances: Die physisch vorhandenen Regler suggerieren funktionale Kontrolle (Perceived Affordance), ohne reale Auswirkung. Dies befriedigt den Nutzerwunsch nach Einflussnahme, während der tatsächliche Mix unverändert bleibt. Es handelt sich um eine bewusste Fehlleitung der Affordances, die psychologische Bedürfnisse (Kontrollillusion) ausnutzt, aber ethisch fragwürdig ist, da sie Transparenz vermeidet.

„false affordance“?

Aufgabe 4: VR-Limitationen

1. **Eingeschränktes Sichtfeld** (110° vs. 180° natürlich)
2. **Verminderte Auflösung** (Screen-Door-Effekt)
3. **Fehlende Tiefenakkmodation** (Fokus-Konvergenz-Konflikt)
4. **Eingeschränkte Haptik** (Keine echte Materialrückmeldung)
5. **Latenz** (Bewegung-zu-Photon-Verzögerung)

*Bewegung im Bild
≠ Gleichgewichtssinn*

Aufgabe 5: k-NN vs. Neuronale Netze

Kein Bezug zur Anwendung!

Aspekt	k-NN	Neuronales Netz
Datenmenge	Berötigt große Livedaten	Braucht große Trainingsdaten
Rechenlast	Hoch bei Vorhersage	Hoch beim Training
Interpretierbarkeit	Nachvollziehbar durch Ähnlichkeit	Black-Box-Modell
Nichtlinearität	Begrenzt durch Metrik	Komplexe Abbildung möglich
Feature-Engineering	Manuelle Skalierung nötig	Automatische Feature-Extraktion

Aufgabe 6: Verkehrsoptimierung

1. **Dynamische Ampelsteuerung** (Reinforcement Learning)
2. **Unfallklassifikation** (Klassifikation)
3. **Verkehrsflussprognose** (Regression)
4. **Verkehrsmusterclustering** (Clustering)
5. **Stauerkennung** (Anomaliedetektion)

nicht in Aufgabe

Aufgabe 7: Visualisierungsformen

1. Choroplethenkarte (Verbrauch pro Geountereinheit)
2. Heatmap für Zeitreihen-Clustering
3. Proportional symbol map (Verbrauch/Pers. als Kreise)
4. Boxplots/Violinplots pro Bezirk
5. Scatterplot-Matrix für Korrelationserkundung

nein

na ja

Aufgabe 8: Animationen

- **Positiv:** Fokussierung, Zustandsübergänge visualisieren, räumliches Mapping
- **Negativ:** Kognitive Überlastung, Interaktionsverzögerung

Aufgabe 9: Evaluationsmethoden

Methoden	+	-
Think-Aloud	Direkte Problemidentifikation	Verhaltensverfälschung
Cognitive Walkthrough	Systematische Fehleranalyse	Keine Nutzerperspektive
Eye-Tracking	Objektive Blickdaten	Hohe Kosten
Logfile-Analyse	Große Datensätze	Keine Ursachenanalyse
SUS-Fragebogen	Benchmark-Vergleich	Subjektive Einschätzung

Kein Bezug zu Anwendung!

Aufgabe 10: Statistische Tests

1. Gepaarter t-Test
2. Chi-Quadrat-Anpassungstest
3. Unabhängiger t-Test
4. Einfaktorielle ANOVA
5. Ein-Stichproben-t-Test